Journal of Research in Progress

HOWARD COMMUNITY COLLEGE

Volume 8 | 2025

HOWARD
COMMUNITY COLLEGE
Journal of Research in Progress

10901 Little Patuxent Parkway
Columbia, MD 21044

On the Cover: This year's cover design is a celebration of collaboration and creativity, featuring a collage of original works by Shannon Davis, Max Gears-Leverknight, and Zachary Neiman. Their pieces reflect the interdisciplinary spirit that defines the Journal of Research in Progress.

Special thanks to Ashleigh Ashburn, Layout and Design Editor, for leading the assembly of the cover design and working directly with contributing student artists to prepare their pieces for publication.

A Note from the Editorial Team...

As we close out another cycle of research, creativity, and collaboration, we are proud to present Volume 8 of the Journal of Research in Progress (JRIP) at Howard Community College. Each volume is a snapshot of where we are and where we're headed—and this year, that sense of forward momentum felt more present than ever.

This volume marks a meaningful shift in our publication's evolution. First, you may have noticed that the logo on this year's cover is different from last year's. HCC adopted new branding just as we were wrapping up Volume 7 so this is our first time using the updated logos throughout. Regarding content, previously, JRIP had gone from having only STEM submissions to incorporating articles representing the social science, arts, and humanities disciplines as well over the last few years. For the first time, this year's volume includes research that is both interdisciplinary and community-based in nature, expanding the scope of what JRIP can be. From STEM to social sciences, arts, and humanities to interdisciplinary, community-engaged scholarship, our contributors pushed boundaries, and we're grateful they trusted us with their scholarly work and art.

Behind the scenes, Volume 8 also reflects progress in our editorial process. We implemented two rounds of peer and faculty review, a practice that deepened the level of engagement and feedback for each submission. Our team of student volunteers including an alumna whose work was featured on last year's cover and whose design and layout contribution was invaluable, played a vital role in final format and layout checks, demonstrating the kind of ownership and pride that keeps this journal thriving.

As always, this issue would not exist without the thoughtful contributions and support of our student authors, artists, peer reviewers, mentors, faculty, staff, and administrator allies. Your commitment to quality and curiosity keeps this journal going.

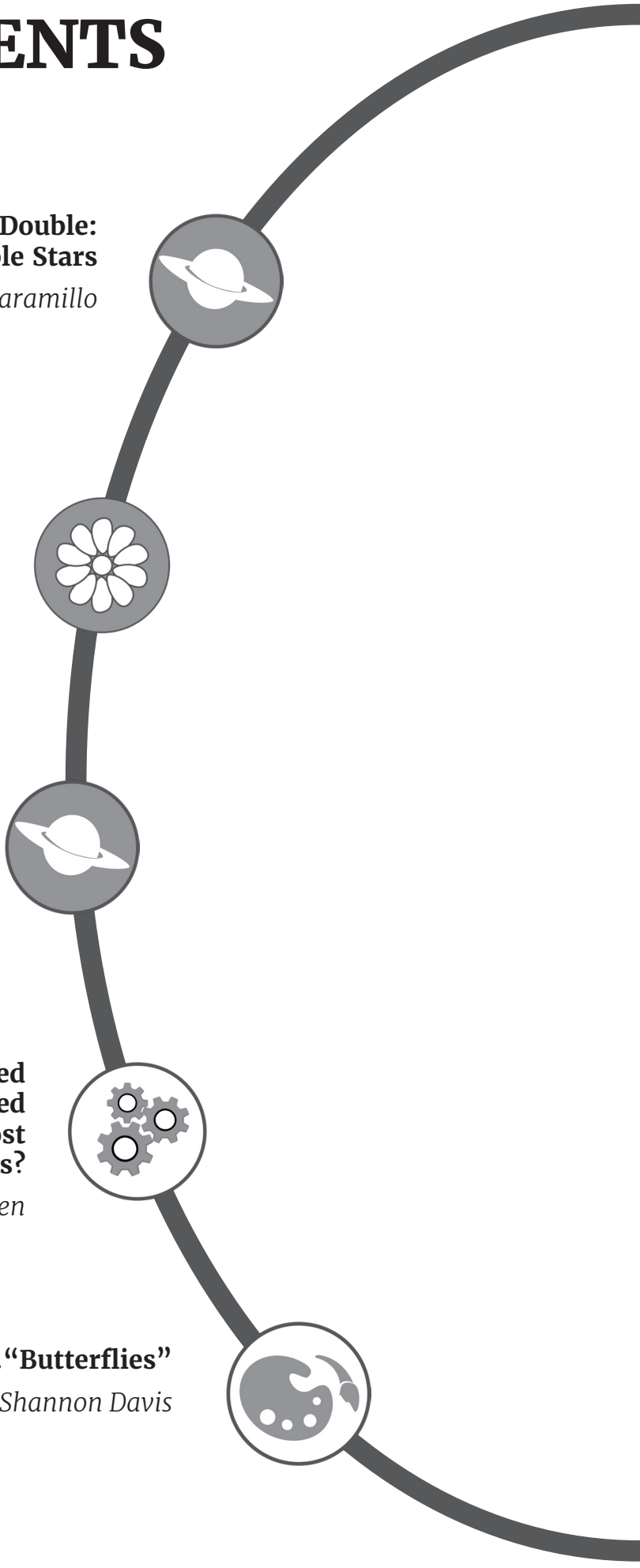
With each year, we uncover new opportunities to grow, streamline, and better serve our diverse community of thinkers. This volume is both a reflection of that learning and a testament to what's possible when we invest in each other's ideas.

In gratitude and service,
The JRIP Editorial Team

Students interested in submitting articles or artwork for next year's volume of JRIP should contact the editorial team at JRIP@howardcc.edu.

An electronic copy of this journal will be available at https://pressbooks.howardcc.edu/jrip8

TABLE OF CONTENTS



Editorial Team

Kristen Lash
Program Manager, Learning Engagment

Sandra Lee
Professor of English and Humanities & World Languages
Division Chair, Liberal Studies

Bethany Pautrat, MD
Assistant Director, Honors and Undergraduate Research

Steven Silberg
Associate Professor of art,
Division Chair, Visual Arts

Kaelyn Sun
Phi Theta Kappa & Schoenbrodt Scholar

Lee Ann Roberts Sweeney, MS, PTA
Instructor of Physical Therapist Assistant

Yingzhe Tao, MA
Coordinator, Honors and Undergraduate Research

Jane H. Wenstrom, Ph.D.
Associate Professor of Mathematics

Rosemary Williams, Ph.D.
Associate Professor of History;
Chair, Social and Natural Sciences

Manya Yazdani
Phi Theta Kappa Scholar

Volume 8 | 2025

Seeing Double: Investigating Unknown Double Stars

Ashley Ekpo, *Howard Community College*
Viviana Jaramillo, *Howard Community College*
Mentored by: Anna DeJong, Ph.D.

Abstract

Double stars are two stars that appear coupled after years of observations. They can either be binary stars, which are gravitationally bound to each other, or simply appear in the same line of sight from Earth. We researched three double star systems with previous observations that had not been confirmed to be gravitationally bound. This project sought to obtain new location data, calculate their celestial coordinates, and plot measurements alongside historical data to determine whether each system is binary. We also sought to update the collective position data for these systems. We used right ascension and declination (the astronomical equivalents of latitude and longitude) to measure the angle and separation between the stars to determine each system's current location. Our findings suggest that system A (WDS 05331+0228 AG 96) does not appear to be binary, while systems B (WDS 07242+1428 J 396 AB) and C (WDS 05145+3634 SEI 114) may be binary but require further measurements for confirmation. Our collected data and calculations were added to the WDS catalog for future analysis by researchers. Additional data analysis and continued observations will be necessary to reach definitive conclusions about these systems.

Introduction

Double stars are two stars that appear close together in the sky. Some double stars are visual only, in that they merely appear to be close together. This is due to parallax, which occurs when an object's position appears to change because of a shift in the observer's point of view [1]. Physical double stars are gravitationally bound to one another and orbit a shared center of mass. Physical doubles are referred to as binary stars. Some binary stars share material, with the recipient pulling stellar material from the donor star [2]. Binary systems can evolve together, as the death of the donor star (the smaller star) can expedite the death of the primary (the larger star) as materials are transferred [3]. Some binary systems can become supergiants, which are larger and brighter than the Sun [4,5]. Increasing fusion reactions can then result in an explosion called a supernova, eliminating the evidence of the system's existence. Larger mass binary systems may result in stellar remnants known as neutron stars, comprised of compressed neutrons, or black holes [2]. Elliptical changes in relative motion indicate the binary nature of a system.

Background

The first documented double star was observed by the astronomer Ptolemy (c.100-c.170AD), entitling it “diplous”, which he observed with the naked-eye [6]. Upon the emergence of the telescope, Benedetto Castelli noted another double star system in the 17th century, consulting with Galileo for its analysis. During the same century, an astronomer, Giovanni Battista Hodierna, compiled a short record of double star findings. Astronomers continued to observe double, triple, and quadruple systems, but the first catalog of observations was not created until the 18th century by astronomer Christian Mayer, which “contained 72 double stars” [6]. A comprehensive longitudinal study of double star observations began with astronomer William Herschel in the late 18th century. Herschel first discovered the function of stellar parallax and defined binary systems as the “union of two stars, that are formed in one system, by the laws of attraction.” [7]. Early observations utilized visual micrometers, which were attached to telescopes for the purpose of measurement. Later, photography aided in system measurements.

In the modern day, speckle interferometry uses light inference for observations once too small to be seen visually. The Washington Visual Double Star Catalog (WDS) maintains the world’s primary double star database and merged previous observation data [8]. The database contains the history of each double star system, including date of observation, position, separation, position angle (angular orientation relative to the other star), magnitude, spectra, and other data points. WDS data is housed at the US Naval Observatory in Washington, D.C. and is available online. Some findings have been published in books and scientific magazines, but today, many reported findings are available in the Journal of Double Star Observations (JDSO). Double star research is a collaborative effort by professional and amateur astronomers as well as physicists who work to compile a more complete record of the movements of these systems throughout our solar system. Because up to half of all stars may become part of binary systems over time, this effort requires a global and generational contribution to chart and project the implications of these stellar relationships [2].

Objectives

Double star research is germane to both the solar historical record and projections for the future. Using telescopic observations, we can measure the location of the secondary star at a given point in time. These measurements, in conjunction with others taken over hundreds of years, help determine if there is an elliptical pattern. If enough data provides evidence of an ellipse, we may be able to make an argument that the double stars are binary in nature. The goal of this research is to add current position data to the historical record and publish it for public access to the greater double star community. Doing so will contribute to the longitudinal findings of these systems and will allow for more accurate conclusions about whether these systems are binary and what we may expect for their outcome in the future.

Methodology

Utilizing Stelle Doppie, the WDS double star searchable database, we researched double star systems that have not yet been determined to be gravitationally bound. Selection criteria for

the uncertain double star systems included the following: right ascension between 2-12, magnitude per square arcsecond between 9-11, delta magnitude less than 4, and separation between 5-10".

Instruments

Observations were made via remote request from the Las Cumbres Observatory (LCO) global telescope network for measurements of all three systems between March 2024 and September 2024. A total of 30 images (10 per system) were captured using a 0.4 meter telescope with SBIG and QHY600 cameras, Bessell V filter, and an exposure time of 3 seconds [13]. Specifically, the observations were conducted in partnership with the Astronomical Observatory in South Africa, the Cerro Tololo Inter-American Observatory in Chile, and the Teide Observatory in Spain, as shown in Figure 1.

Figure 1: *0.4 m telescope located at one of Teide Observatory's sites [14]*

Measurements

Images from the LCO database were downloaded, reduced, and analyzed using Afterglow Workbench (see Figure 2), a software which allows for image scaling, measurement and labeling. Afterglow Workbench allows for measuring the angular separation and position angle (PA) between the primary and secondary stars. Saturation levels were adjusted to optimize the image clarity with clean separation of the stars. Finally, the right ascension (RA) and PA were confirmed to match Stella Doppie.

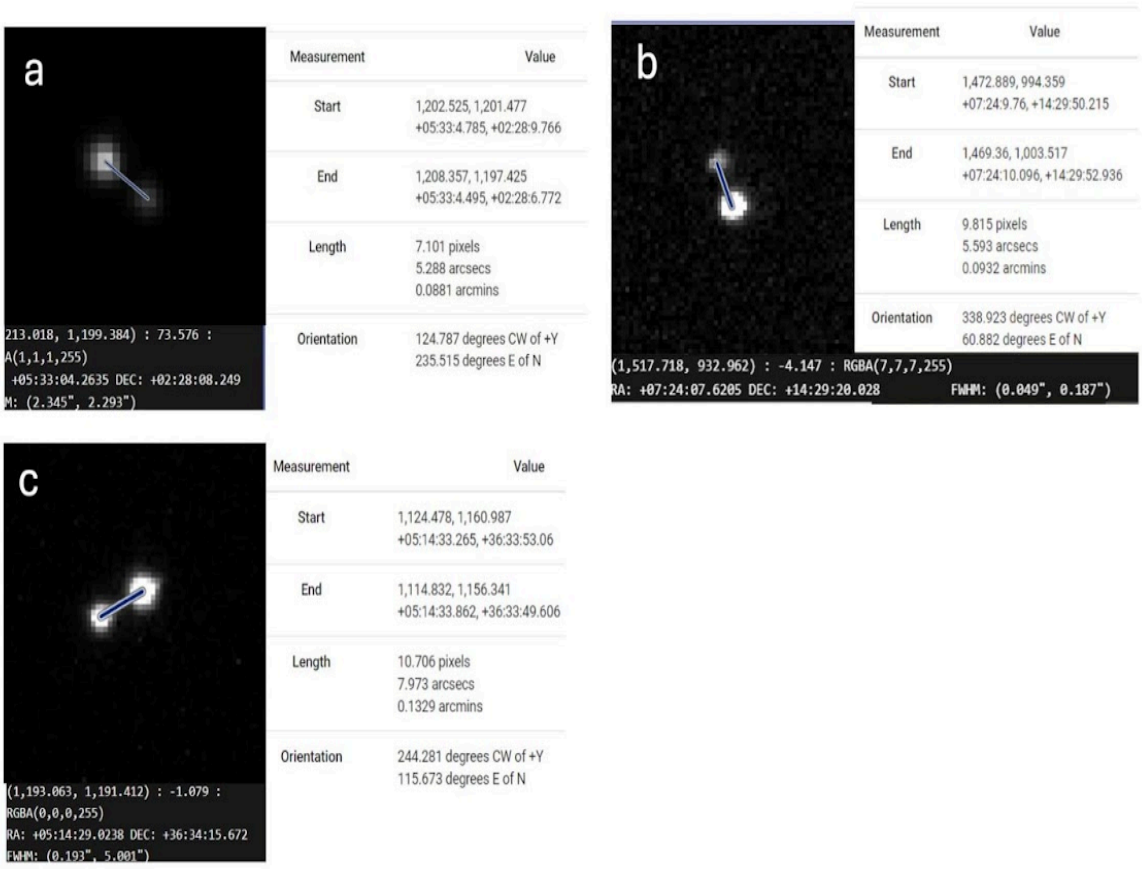


Figure 2: *Afterglow Workbench sample measurements of the three systems: Figure 2a: WDS 05331+0228 AG 96 (HD 288012) Figure 2b: WDS 07242+1428 J 396 AB and Figure 2c: WDS 05145+3634 SEI 114 (HD 280693)*

A total of 10 measurements were taken to minimize error due to imaging shifts, pixelation, scintillation (the twinkling of stars due to atmospheric changes), and intensity variations. The position angle and separation were converted into x-y coordinates to be able to be plotted on a cartesian plane using the following formulas:

$$x = Sep \cdot sin(PA) \tag{1}$$

$$y = -\ Sep \cdot cos(PA) \tag{2}$$

where *Sep* is the separation and PA is the position angle.

Data

The separation and position angle for each of the 10 images measured in Afterglow Workbench were calculated using Formulas 1 and 2 and are reflected in Tables 1-3. The average of each system's measured separation and position angle were then calculated and noted in Table 4.

Date	Separation (arcsec ")	Position Angle (°)
2024	5.464	235.029
	5.253	235.548
	5.360	234.975
	5.192	234.500
	5.143	234.091
	5.347	234.805
	5.348	235.247
	5.304	235.507
	5.350	235.442
	5.315	235.574

Table 1: *Measurements with Afterglow Workbench of WDS 05331+0228 AG 96 (HD 288012), System A*

Date	Separation (arcsec ")	Position Angle (°)
2024	5.618	61.091
	5.593	60.882
	5.739	61.178
	5.754	60.901
	5.766	61.153
	5.824	62.684
	5.680	60.820
	5.768	61.416
	5.756	61.621
	5.698	62.994

Table 2: *Measurements with Afterglow Workbench of WDS 07242+1428 J 396 AB, System B*

Date	Separation (arcsec ")	Position Angle (°)
2024	7.973	115.673
	8.005	115.634
	7.953	117.055
	7.999	116.142
	7.928	116.007
	8.116	116.481
	8.11	116.459
	8.203	115.840
	8.044	116.252
	8.051	116.748

Table 3: *Measurements with Afterglow Workbench of WDS 05145+3634 SEI 114 (HD 280693), System C*

System	Date	Number of Images	Magnitude	Position Angle (θ)	Standard Error on Position Angle	Separation (ρ)	Standard Error on Separation
WDS 05331+0228 AG 96 (HD 288012)	2024.19	10	9.66	235.1°	0.16	5.31"	0.029
WDS 07242+1428 J 396 AB	2024.17	10	9.12	61.7°	0.29	5.71"	0.023
WDS 05145+3634 SEI 114 (HD 280693)	2024.68	10	10.74	116.2°	0.75	8.04"	0.14

Table 4: *Summary of measurements*

Results

Our measurements are plotted in Figure 3 with the available historical data for each system for comparison. The horizontal axis is right ascension or RA (arcseconds), and the vertical axis is declination or DEC (arcseconds). The primary star of the system is as noted and the secondary star is plotted on the graph. By plotting the new measurement alongside the historical data, the changes in relative motion of the stars can be seen. The new measurements were compared to the historical coordinates to determine if there was evidence that the systems were binary in nature.

Figure 3a, representing system A, shows the origin at the top right with a star representing the primary star. The different colors indicate different times in which the data was collected, dating back to 1901. The graph indicates that the older points tend to be more widely spaced, while recent data points appear more clustered. This trend may be due to historical telescope limitations, which could have led to less precise measurements in earlier observations. The current data point follows this pattern, as it appears in the middle of the cluster. Since there is little motion toward or away from the primary star in the more recent data, it suggests that this system is likely not gravitationally bound.

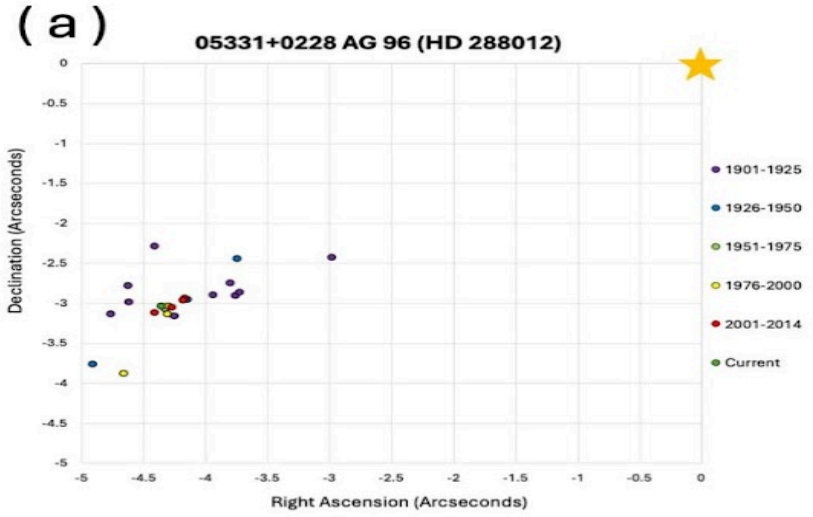


***Figure 3a**: Plot of historical and current data for WDS 05331+0228 AG 96 (HD 288012)*

Figure 3b, representing system B, has the origin at the upper left, just off of the graph. A trend seems to appear where the secondary star is moving slightly to the right, increasing in right ascension. The 1911–1943 data cluster (blue) is located around a right ascension of 4 arcseconds, while more recent measurements (orange and red) are closer to 5 arcseconds. This indicates that the star has shifted position gradually over the century and is moving away from the main star. The declination has had minor changes towards slightly less negative values in more recent observations. There also seems to be two outliers which are noticeably separated from their main cluster. The outlier in the blue cluster is farther to the left, around a right ascension of 3.25 arcseconds, than the rest of the blue points, which are clustered around a right ascension of 4.25 arcseconds. The outlier in the orange cluster is farther to the right than the rest of the orange

points, which are clustered around a right ascension of 5.0 arcseconds. These outliers could again be due to historical telescope limitations. Based on the overall trend, this system has the possibility of being either gravitationally bound or simply drifting apart from Earth's point of view.

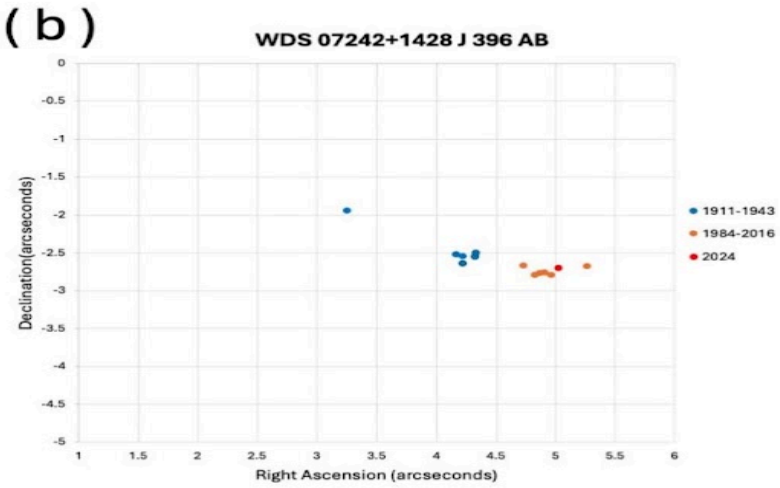


***Figure 3b**: Plot of historical and current data for WDS 07242+1428 J 396 AB*

Figure 3c, representing system C, has the origin at the lower left on the x-axis, just off the graph. The secondary star shows significant changes between data points from 1895-1935 and 2000-2024. Data points in the 1895-1935 range represent an outlier in the data, which may, like systems A and B, be reflective of historical telescope limitations. Over time, there is a very steady decrease in the right ascension and a more significant decrease in the declination. Since 1935, each decade has an even cluster, with each subsequent generation closer to the primary star than the last. These results suggest a shift toward the primary star and an indication that this system may be gravitationally bound.

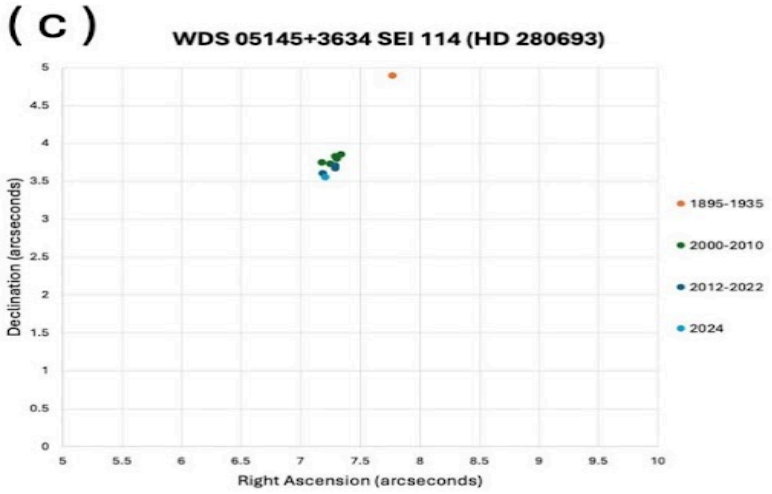


***Figure 3c**: Plot of historical and current data for WDS 05145+3634 SEI 114 (HD 28069*

Overall, in each system, the number of points is not sufficient to establish a clear orbital pattern. More frequent observations over time are needed to better understand the trajectory of the stars.

Conclusion

By looking at the separation and position angle of the stars and comparing these to historical data points, we made the best possible estimates of whether the systems are gravitationally bound given the available data. Our results suggest that it is unlikely that system A (WDS 05331+0228 AG 96) is binary, whereas systems B (WDS 07242+1428 J 396 AB) and C (WDS 05145+3634 SEI 114) may very well be binary. For each system, further measurements are needed to make more complete conclusions.

While we were unable to reach a confirmatory conclusion on whether the stars are binary, we successfully fulfilled our goal of adding more recent data to each system. In the future, these systems should be analyzed again to see if any changes occur.

Ongoing Work

Upon the conclusion of this research, a scholarly publication of the findings was submitted to the JDSO for consideration in their next journal edition. Publication in the JDSO will make the data from these systems available to WDS via Stelle Doppie and accessible to the greater astronomy community for further research.

Acknowledgements

This research was made possible by the Washington Double Star catalog maintained by the U.S. Naval Observatory, the Stelle Doppie catalog maintained by Gianluca Sordiglioni, Las Cumbres Observatory, and the Afterglow Workbench software.

This work has also made use of data from the European Space Agency (ESA) mission Gaia (https:// www.cosmos.esa.int/gaia) and processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, particularly the institutions participating in the Gaia Multilateral Agreement.

This work makes use of observations taken by the 0.4 m telescopes of Las Cumbres Observatory Global Telescope Network located at the Cerro Tololo Inter-American Observatory, the Teide Observatory in Spain, and the Astronomical Observatory in South Africa.

Contact: ashleyekpo@hotmail.com, vjaramillo019@gmail.com

References

[1] "Stellar Parallax," *Las Cumbres Observatory*. https://lco.global/spacebook/distance/parallax-and-distance-measurement/

[2] "The Evolution of Binary Star Systems | Astronomy." https://courses.lumenlearning.com/suny-astronomy/chapter/the-evolution-of-binary-star-systems/#:~:text=Figure%201%3A%20Evolution%20of%20a,to%20become%20a%20red%20giant

[3] "Double Stars - NIU - Department of Physics," *Northern Illinois University*. https://www.niu.edu/clas/physics/observatory/honors-project/double-stars.shtml

[4] A. Cermak and N. U. W. Team, "Multiple Star Systems - NASA Science," *NASA Science*, Oct. 22, 2024. https://science.nasa.gov/universe/stars/multiple-star-systems/

[5] "IAU Office of Astronomy for Education." https://astro4edu.org/resources/glossary/term/347/

[6] J. González-Payo and J. A. Caballero, "Discovery of double stars by Giovanni Battista Hodierna in 1654," *Monthly Notices of the Royal Astronomical Society*, vol. 533, no. 3, pp. 3379–3386, Aug. 2024, doi: 10.1093/mnras/stae2010.

[7] "What We Know About Double Stars. (George Darwin Lecture, delivered by Dr. R. G. Aitken, Assoc.R.A.S., on 1932 May 13.)," *Monthly Notices of the Royal Astronomical Society*, vol. 92, no. 7, pp. 596–609, May 1932, doi: 10.1093/mnras/92.7.596.

[8] "The Washington Double Star - Description | USNO." https://crf.usno.navy.mil/wdstext

[9] J. Gregorio-Hetem, J. R. D. Lepine, G. R. Quast, C. a. O. Torres, and R. De La Reza, "A search for T Tauri stars based on the IRAS point source catalog.," *The Astronomical Journal*, vol. 103, p. 549, Feb. 1992, doi: 10.1086/116082.

[10] J. Serot, "Speckle Interferometry of Close Visual Binaries with a 280 ..." *Journal of Double Star Observations*, Jun. 2016. [Online]. Available: www.jdso.org/volume12/number5/Serot_488_499.pdf

[11] R.J. Muller *et al*., "Using the Separation of Double Stars to Obtain the Plate ..." *Journal of Double Star Observations*, Summer 2008. [Online]. Available: www.jdso.org/volume4/number3/muller.pdf

[12] E. Berk´O and G. Vask´Uti, "Measures of Double Stars with a DSLR Camera and 35.5-Cm Reflector from 2007.109 to 2007.191," *Double Star Section Circulars*, vol. No 16, 2008, [Online]. Available: https://www.webbdeepsky.com/dssc/dssc16.pdf

[13] T. M. Brown *et al.*, "Las cumbres Observatory Global Telescope Network," *Publications of the Astronomical Society of the Pacific*, vol. 125, no. 931, pp. 1031–1055, Sep. 2013, doi: 10.1086/673168.

[14] “Gallery image Night View of the Two New Domes Housing 1m Telescopes at Teide Observatory.jpg.” https://lco.global/gallery/image/414/

First-Year Native Garden Impacts on Insects and Humans in Suburban Communities

Andrew Heffner, *Howard Community College*
Mentored by: Cheryl J. Campo, Ph.D., J.D.

Abstract

This research investigates the impact of first-year native gardens on insects and humans in suburban communities in order to see how small-scale projects could potentially create large-scale cultural shifts, placing ecological value over aesthetic/human value. This was done by planting research gardens in community spaces with the help of at least one community participant who agreed to care for the garden. In total, nine sites of approximately 50 square feet with varying environmental conditions and participant knowledge were selected. Insect visitation was tracked during site visits and utilized a simple counting method. Human metrics were measured using a pre-garden survey and post-garden survey. Overall findings show that while insect visitation varies depending on a variety of environmental conditions, human attitudes towards native plants were more positive and people were more likely to consider ecological impacts of plants over just aesthetics.

Introduction

Native plants and animals have coevolved with other flora and fauna for thousands of years and are adapted to survive in specific conditions [4]. Because plants are the base of terrestrial food chains and provide essential ecosystem services, they are of special interest to preserve in order to maintain biodiverse ecosystems and mitigate the devastating effects of climate change. Anthropogenic habitat loss and unsustainable landscaping practices, such as grass lawns and invasive plants, have played a role in the steep decline in biodiversity worldwide, which can have catastrophic impacts on the environment and humans [11, 12]. Without biodiversity, we can expect to see a decline in ecosystem services, such as clean water and air, natural resources, and especially relevant for the state of Maryland, coastal protection [11].

Using native plants in garden settings could have positive impacts on local biodiversity. Previous studies looking at insect preferences between native and non-native gardens have had mixed results but show promising data that native gardens support specialist bees as the specialist bees have a limited palette of flowers they can feed from [10, 8, 4, 3, 2]. The main

conclusion from these studies was that overall flower abundance had the greatest influence on insect activity [10, 8, 3].

However, flowers are not the only part of plants that are utilized by insects. Many species require a host plant to complete their life cycle and create the next generation of insects. The most famous example of this is the monarch butterfly and milkweed. While the monarch butterfly can eat nectar from many different flowers, it will only lay its eggs on species of milkweed and the caterpillars will exclusively feed on milkweed vegetation. Species of gall-producing insects (insects that utilize abnormal plant growth for reproduction) have been found to favor their native host species over non-native species, indicating that planting native species can increase insect numbers [9]. A similar study looked at how a generalist (an insect that can use a plethora of plants) aphid species used two rhododendron species as a host plant. One rhododendron was their preferred host plant, while the other was non-native and invasive. The researchers found that the generalist aphid species could ingest the invasive plant, but were not able to survive or reproduce, which they were able to do on their regular host plants [7].

Native plants have been shown to support biodiversity in suburban settings. In a study done in California, native and non-native landscaping was compared and measured in terms of bird support. They found that native landscaped yards had an increased number and diversity of bird visitors, as well as increased observed feeding behaviors in native yards. This study didn't only look at plant matter, but also habitat features, such as leaf litter, which may have tasty overwintering insects for birds. Because the native plants supported insects, it was also able to support birds, thus reinforcing the importance of plants as the base of terrestrial ecosystems. The findings from the study also support that a native garden provides ecological benefits throughout the entire year, not just when the plants are actively growing and flowering [6].

Garden spaces can serve as a form of green space and beautification in suburban settings. One study looked at how wealth impacted the effects of green spaces on community health. The researchers found that in wealthier cities, increasing green space does appear to increase wellbeing for citizens, but for poorer cities, increasing green space negatively affects wellbeing. The researchers discuss that this could be because of the difference in quality of the green spaces between wealthy and poor cities. They point out that poor cities may not have funding to maintain upkeep and safety of green spaces, leading to increased crime, vacant buildings, graffiti, and other drawbacks that may evoke fear in citizens [5]. For this study, it is important to note that the area the sites were planted in is a fairly wealthy suburb. Therefore, the maintenance aspect of the native gardens is increasingly important, as aesthetics are vital for whether people view the garden as a mess of weeds or as a functioning ecosystem.

Connecting people to plants is not as simple as showing an infographic or stating facts. For people's attitudes towards native plants to change, there must be a social and cultural shift, which takes a great deal of time, money, and effort [1]. There is a gap in knowledge regarding native plants and how community outreach could impact cultural attitudes towards native plants in a short amount of time. This paper seeks to fill that gap in an upper middle-class suburb by offering free gardens and increasing community involvement with native plants. As a result of this project, it is hypothesized that insect abundance will increase after the gardens are installed and that people's knowledge of native plants will increase, their likelihood of planting native

plants in their own yard will increase, they will pay attention to species origin and ecological impacts of plants before purchasing them, their view of native plants will be more positive, and they will feel more connected to their community because of the gardens.

Methods

Site selection was based on proximity to the research institution and willingness of the participants to care for the garden. Sites had to be within a 10-minute drive from the institution (Fig. 1). Native plant selection for each garden was based on the site's conditions, such as sunlight and moisture level, as well as overall plant availability and aesthetic appeal to the community it was planted in (Table 1). As there was no funding for the project, plants were procured through community connections and from seeds planted in December 2023. Plants varied in their soil condition, age, and size when planted.

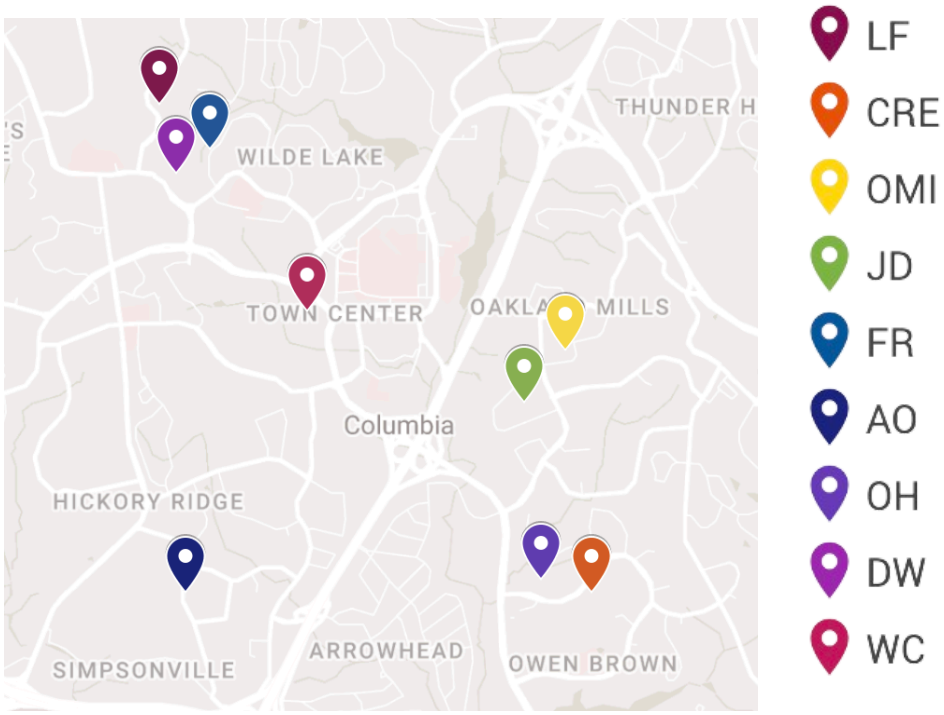


***Figure 1**: Location of all nine sites across Columbia, MD.*

Site	Plants
CRE	*Phlox subulata*, *Rudbeckia hirta*, *Echinacea purpurea*, *Onoclea sensibilis*, *Solidago altissima*, *Phlox paniculata* (cultivar), *Carex* spp. (2 species), *Pycnanthemum muticum*, *Tradescantia ohiensis*, *Tiarella cordifolia*, *Aquilegia canadensis*, *Oenothera biennis*, *Eurybia divaricata*
LF	*Monarda fistulosa*, *Pycnanthemum muticum*, *Solidago* sp. (local ecotype), *Symphyotrichum novae-angliae*, *Packera aurea*, *Anemone canadensis*, *Sisyrinchium angustifolium*
OMI	*Solidago altissima*, *Penstemon digitalis*, *Liatris spicata*, *Packera aurea*, *Oenothera biennis*, *Asclepias tuberosa*
JD	*Solidago* spp. (2 species, volunteering), *Pycnanthemum muticum*, *Monarda fistulosa*, *Sisyrinchium angustifolium*, *Tiarella cordifolia*, *Packera aurea*
FR	*Matteuccia struthiopteris*, *Sisyrinchium angustifolium*, *Tiarella cordifolia*, *Carex* spp. (2 species), *Packera aurea*, *Heuchera* spp.
AO	*Penstemon digitalis*, *Rudbeckia hirta*, *Rudbeckia fulgida*, *Eryngium yuccifolium*, *Coreopsis lanceolata*, *Sisyrinchium angustifolium*, *Packera aurea*
OH	*Penstemon digitalis*, *Coreopsis verticillata*, *Packera aurea*, *Rudbeckia fulgida*, *Echinacea purpurea*, *Phlox subulata*, *Sisyrinchium angustifolium*
WC	*Matteuccia struthiopteris*, *Amelanchier arborea*, *Iris cristata*, *Eurybia schreberi*, *Geranium maculatum*, *Tradescantia ohiensis*, *Asarum canadense*, *Phlox paniculata* (cultivar), *Penstemon digitalis*, *Penstemon smallii*, *Monarda fistulosa*, *Liatris spicata*, *Carex* spp. (2 species), *Tiarella cordifolia*
DW	*Heuchera* (cultivar), *Packera aurea*, *Matteuccia struthiopteris*, *Onoclea sensibilis*, *Osmundastrum cinnamomeum*, *Adiantum pedatum*, *Sedum ternatum*, *Lobelia cardinalis*, *Lobelia siphilitica*, *Solidago caesia*, *Salvia lyrata*, *Asarum canadense*, *Chelone glabra*

***Table 1**: Table of the species planted at each site.*

Both insect and human sets of data were collected from June to November 2024. For the insect data set, a procedure was adapted from a similar study in which the researcher stood in the same place during each visit and counted how many insects they saw in one minute [10]. This method was selected to measure the abundance of both bees and other flying insects at each site. Visits were conducted under ideal weather conditions, which were sunny or partly cloudy with no precipitation. General weather conditions needed to remain the same across visits, as data collected during different weather conditions would reflect impacts based on weather instead of impacts based on plants. Visits were conducted on an approximately weekly basis and all sites had one pre-garden data point. Multiple photos of the sites were taken during visits. Starting with the third round of visits, a hand-width was used as a scale reference in order to visually track general growth trends of the plants.

Regarding the human participants, the research aimed to measure how engaging community members in planting and maintaining native gardens affected their thoughts, attitudes, and actions surrounding native plants. This was done by having two IRB-certified surveys of the participants: a pre-garden survey taken before the garden was planted and a post-garden survey taken in November after the participants had cared for the gardens throughout the 2024 growing season. Likert scales ranging from 1-5 (1 was negative while 5 was

positive) were used for the survey question responses in order to best compare the pre- and post-data. Participants were given instructions prior to the garden installation regarding maintaining the gardens, such as watering, weeding, potential clean up, and what to expect in future years as the gardens mature.

Results

It was found that while bee and flying insect visitation did increase in comparison to pre-garden numbers, the data varied greatly from site to site, most likely due to the varied environmental conditions and a correlation to the presence of impervious surfaces, such as asphalt or concrete (Table 2).

Visit Date	CRE	OH	OMI	JD	AO	WC	FR	DW	LF
0	0	0	0	0	0	0	0	0	0
12-Jul	1	4	0	1	0	4	13	3	4
2-Sep	0	0	0	0	1	2	7	9	11
15-Sep	0	0	1	1	2	0	11	3	4
22-Sep	0	0	1	0	4	0	3	0	4
6-Oct	2	4	1	1	2	31	12	2	11
13-Oct	5	1	0	0	0	19	11	4	7
27-Oct	0	0	0	0	7	1	2	1	1
3-Nov	0	0	0	0	3	0	0	2	2

***Table 2**: Flying insects and bees at each site per visit date. "0" date represents data collected before the garden was installed.*

Positive and negative controls were added during the third visit. The positive control was a mature native garden located on OMI's property, and the negative control was a maintained grass lawn also located on OMI's property. Surveyed areas for each control are outlined in red and are approximately 50 square feet (Fig. 2). The general trend from the controls is that the positive control was consistent at attracting flying insects, especially bees, while the grass lawn was more sporadic. Additionally, insects found on the positive control had a clear use for the plants, as they were visiting the flowers. Sites that mimic the negative control are CRE, OH, OMI, JD, and AO, while sites that mimic the positive control are WC, FR, DW, and LF. The sites that are more similar to the negative control are also sites located closer to impervious surfaces, while sites that are more similar to the positive control are located near more natural areas.

***Figure 2**: Left shows the positive control mature native garden. Right shows the negative control grass lawn.*

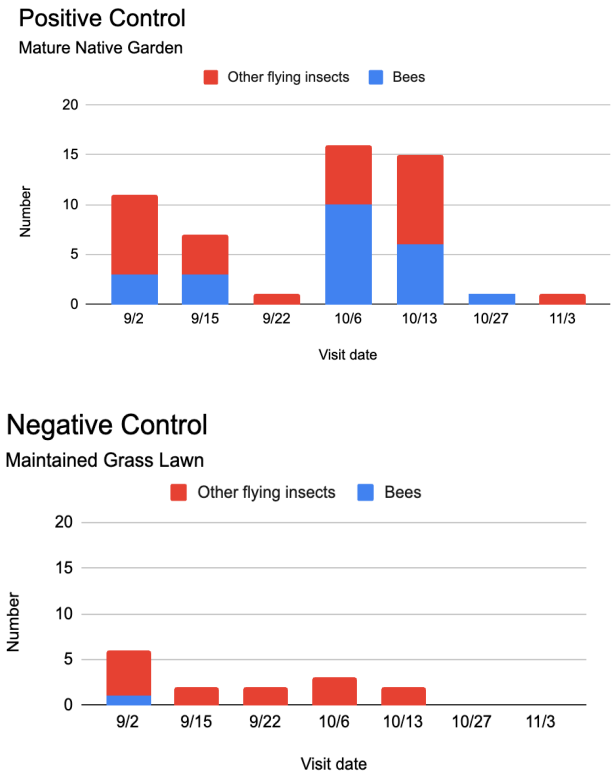


Figure 3: *Data from the positive and negative control sites. Control sites have the same conditions and are located at the same facility. Monitored portion of the control sites was roughly the same as gardens (~50 sq ft).*

The human data set was less variable, and metrics increased in line with the hypothesized outcomes across the board from the pre to post-survey. People's self-reported knowledge of native plants increased substantially (Fig. 4), their overall view of native plants increased positively (Fig. 5), they favored environmental impacts of plants over aesthetics (Fig. 6), and they were more likely to pay attention to the origin of plants before making hypothetical purchases (Fig. 7). As a note, one extra participant took the pre-survey (n=10), but did not complete the post-survey (n=9).

While participants were educated about native plants and their benefits during the garden installation process and were provided an electronic handout, the dramatic increase in self-reported knowledge on native plants is impressive. The pre-survey's average was a 2.9, while the post-survey's average was a 3.8, where no one reported anything below a 3 (Fig. 4). The reason the number of responses of 5 may have decreased is that people forgot what they had reported on the pre-survey, or as they continued to seek out information on native plants, they realized that their previous scope of knowledge was limited. Nonetheless, this suggests that people did research on their own to educate themselves about native plants. This might have affected the rest of the results, as the more they researched, the more they learned about the ecological importance of native plants.

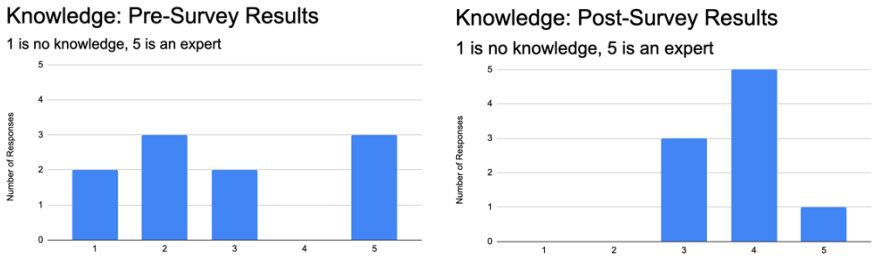


***Figure 4**: Participants knowledge of native plants. Knowledge of native plants increased.*

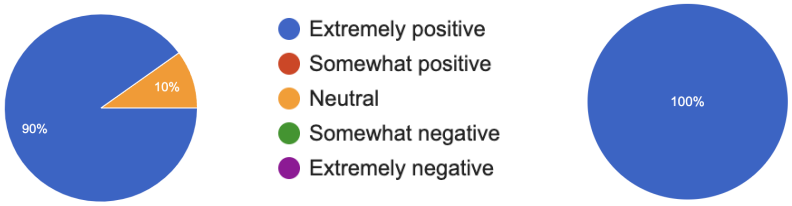


***Figure 5**: Pre (left) vs. Post (right) view of native plants. One hundred percent of people in the Post survey rated their view of native plants as extremely positive, compared to 90% in the Pre survey.*

People's potential purchases changed because of the gardens, with more people reporting that they consider environmental impacts more than just aesthetics (Fig. 6) and most were very likely to pay attention to plant species' place of origin before purchasing them (Fig. 7) There was also a 20% increase in the number of people who reported that they had a native plant in their yard (Fig. 8). This means that because people engaged with native plants, they intentionally sought out native species to purchase for their own landscaping. These results have broader implications for the landscaping market and could increase native plant sales while decreasing exotic and invasive plant sales.

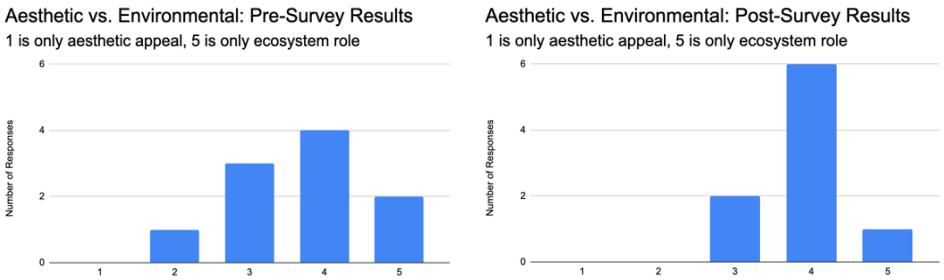


***Figure 6**: Environmental vs. aesthetic considerations when purchasing plants. People are more likely to consider environmental impacts over aesthetics after their experience with the gardens.*

***Figure 7**: Pre (left) vs. Post (right) survey measuring the likelihood to pay attention to where a plant comes from and its role in an ecosystem before purchasing it. People are more likely to pay attention to species origin and ecosystem roles when buying plants.*

***Figure 8**: Pre (left) vs. Post (right) survey results where participants were asked if they had any native plants in their yard. There was a 20% increase in the number of people who responded "yes".*

Additionally, participants were asked to rate how connected their community felt as a direct result of the garden. Because of the gardens, community connectivity increased. The pre-survey's average response was a 3.3, while the post-survey's average response was a 3.6 (Fig. 9). When people have a common goal to care for something, it brings them together and causes people to build connections in their community, as multiple participants reported that the gardens increased community engagement (see Appendix).

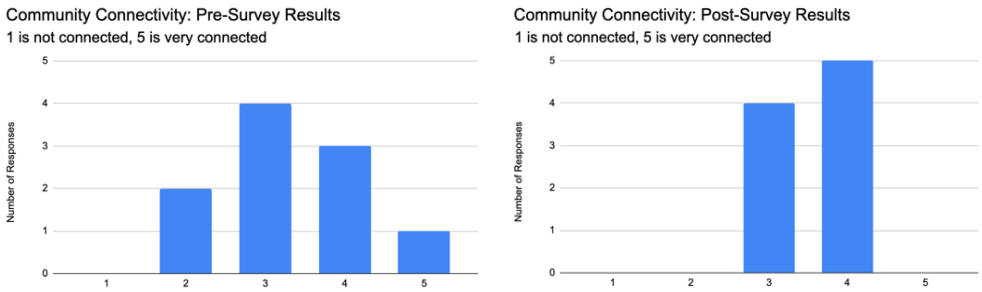


***Figure 9**: How well participants felt their community was connected, specifically in relation to this project. People felt that their community was more connected because of the gardens.*

Discussion

The findings suggest that when communities are engaged with the native garden process and subsequent care, they are more likely to have a positive view of native plants, incorporate them into their landscape, and spearhead community plantings of their own. This outcome has already been seen with the research site FR, as the participant wrote, "The project helped to

springboard and contribute to larger efforts to eliminate invasives." The community has since removed all of the invasives from their hillside and collaborated with their local community association to create an "Adopt-a-Spot" native garden at the bottom of their property (Fig 10).

***Figure 10**: FR community planting an Adopt a Spot adjacent to research site in the fall.*

Impervious surfaces seem to play a role in how insects find native plants. Sites that were surrounded by or located near impervious surfaces saw far fewer insects than those in or near pervious surfaces (data shown in Appendix). These sites' data is more closely aligned with the negative control data. It is possible that being located adjacent to natural environments that support insects improves the likelihood of insects finding a new habitat source (garden). Since this data is just from the first year, it is expected that as the plants mature and flower, more insects will find them and use them for reproduction, increasing the amount of insects using the gardens.

Flowers may also not be the biggest factor that attracts insects, as many sites had flowers but did not see an increase in insect visits. The only flower to significantly impact insect visits was the blue wood aster at WC. This may be because of the sheer volume of flowers, the large number of species the plant is known to support, and/or being surrounded by pervious surfaces.

Plants

Growth of the plants varied greatly, both between sites and between plant species. While no measurements were officially taken, a hand was used for scale to visually track general growth trends. In general, plants that were already established in soil prior to planting performed better than those that were bare root at the time of planting. It is recommended that plants are either purchased/sourced as soil-established plants or that plants are planted in a soil medium and rooted out before planting as opposed to being stored as bare root and then planted at the site.

Some plants outperformed others. Two species of note that bounced back from presumable death were golden ragwort (*Packera aurea*) and moss phlox (*Phlox subulata*). *Packera aurea*, despite being planted bare root, survived at all sites it was planted at and spread throughout the growing season. It grew in all site conditions, from dry and sunny (OH) to moist

and shady (FR). As it is a groundcover plant, it is expected to spread throughout the following years to create a living mulch.

***Figure 11**: From left to right: Packera at DW site spreading, Packera with signs of insect usage at LF, and Packera at FR.*

Moss phlox was only planted at the OH site as a bare root and struggled throughout the brutal heat of summer but notably started to put on more vegetative growth during fall.

***Figure 12**: Comparison of growth of moss phlox at OH.*

Foxglove beardtongue (*Penstemon digitalis*) performed well at most sites, putting on foliar growth in both sunny and shady conditions. All three of the previous plants mentioned bloom around spring-early summer, so they did not bloom the first year and instead focused on foliar growth.

***Figure 13**: From left to right: Penstemon digitalis at AO, OMI, WC, and OH.*

Orange coneflower (*Rudbeckia fulgida*) performed well at the OH site, which was the only site it was planted in. They were planted as quart sizes and didn't seem to do well until fall, which welcomed rain and cooler temperatures. These plants bloomed the longest, from September to November.

***Figure 14**: Left shows orange coneflower in bloom at OH site during September. Comparison of shady-side (middle) and sunny-side (right) growth of orange coneflower.*

Blue wood aster (*Symphyotrichum cordifolium*) was the most prolific plant in terms of flower production. When it bloomed in fall, it was approximately five feet tall and covered in small blue flowers that attracted a plethora of flying insects. For immediate positive results for pollinators, most species of asters are recommended, as they will bloom the same year they are planted with a high amount of flowers.

***Figure 15**: Left shows an insect pollinating blue wood aster. Middle shows the height of blue wood aster. Right shows the mass of blooms from three plants.*

This same logic can also be applied to many species of goldenrods (Solidago). *Solidago altissima* and *flexicaulis* bloomed during the fall, but *Solidago altissima* was much shorter than the expected 6-9ft tall plants, as it was only about 1.5ft tall. Another late season bloomer that flowered was great blue lobelia (*Lobelia siphilitica*).

***Figure 16**: Left shows Solidago altissima at OMI. Middle shows Solidago flexicaulis at WC. Right shows great blue lobelia at DW.*

In general, plants that have later bloom times should be planted for immediate first-year impacts of native gardens. Aster and goldenrod species are of particular interest because of their performance in this study, as well as being keystone species.

Conclusion

The results have profound implications for the future of native plants, sustainable landscaping, and shifting cultural norms regarding gardens in America. While this study only focused on growth in a single year, these gardens are expected to significantly increase in plant biomass and subsequently insect visitation, as more insects will find these gardens and use them for food, shelter, and reproduction. It is thought that as the gardens mature, people's attitudes will continue to favor native plants as they care for the gardens and see the interactions between wildlife and plants flourish. This could also encourage more community members to engage with the native gardens, leading to continued community support for native plants, increasing habitat, and decreasing lawns and invasive plants.

A future study could investigate how the garden's distance from impervious surfaces and overall impervious surface cover affects insect abundance over time, as it was found that sites located near or surrounded by impervious surfaces had overall lower insect visits than those surrounded by previous surfaces. This could give insight into where native gardens should be planted within a community to maximize the ecological potential of the garden. Additionally, time of planting may be a factor. Planting gardens in spring or fall would help to avoid the high summer temperatures and potential droughts while the plants become established.

Because the project was self-funded, considerable time was focused on sourcing plant species at varying stages of development and there was a limited amount of time to monitor the nine widely-spaced garden sites. Receiving funds to procure plants at more similar stages of growth prior to planting, as well as personnel to travel to and collect data from the gardens, would have also made it possible to collect a larger range of plant data, such as height and spread over time.

A limitation of the field data method used was that it was difficult to tell insects apart from the observing distance, so some data may be unreliable (as in some bees may have been grouped into the other flying insect group and vice versa). Additionally, on the few days when there was high insect abundance, keeping track of the count of each group proved difficult. Future studies should aim to use a capture-and-ID method for measuring insect abundance, where researchers collect insects from the sites, then bring those insects back to a lab to identify them. This would allow researchers to clearly identify which insects were and were not bees, as well as identify if those insects were native or non-native to the region and if they were specialists or generalists.

Another possible direction would be to see how people's attitudes and actions change depending on the price of a garden. It is worth considering if people would care more for one that they paid a small sum for because they had a monetary investment or if a monetary price would drive away interest. Additionally, another study could investigate how the resources provided to participants influence their overall experience with the gardens, and subsequently, how they view native plants. It is hoped that continuing this line of research will eventually lead to increased funding towards making native plants more accessible to communities which, when compounded, could lead to increased ecosystem services and biodiversity, thus creating a healthier and safer environment for us all.

Acknowledgements

All the native plants in the gardens were donated, making this all possible. A huge thank you is given to all the native gardeners who supported this effort by donating their plants: Howard Gordin, Alina Sopiep, Julie Danna, Bess Caplan, Catherine Berruer Ojo, Stephanie Bills, Susie Kantt, Dianne Beer Maxwell, Bena Zhang, Kathy Kaberle, Carol Fain, Cassandra Hostetler, Wendy Hall, Alicia Eugenia Ardila, Jamie Modico, Martha Betz, Katie Schmitt, Barbara Ridler White, Phannie Truong, and Erica Leventhal. The following people are recognized for their considerable contributions on behalf of their respective organizations: Don Georgette (Sustainable Landscapes VA-MD), Natalie Yee (Columbia Association), and Julie

Costantino (Howard County Bee City). A special thank you is given to the Facebook groups of "Maryland Gardening for the Environmentally Conscious" and "Howard County Gardeners". The participants' hard work and continued efforts into caring for the gardens and maintaining them for years to come is also recognized.

Contact: andrew.heffner@howardcc.edu

Appendix

Please scan the QR Code below to view an electronic version of the Appendix. It includes detailed information on each of the nine research sites, including location, environmental conditions, site preparation, notes, participant comments, and photos.

References

[1] B. R. Beckwith, E. M. Johansson, and V. J. Huff. "Connecting people, plants and place: A native plant society's journey towards a community of practice." *People and Nature*, vol. 4, no. 6, Jun. 2022, doi: https://doi.org/10.1002/pan3.10368.

[2] C. A. M. Marshall *et al.* "Urban wildflower meadow planting for biodiversity, climate and society: An evaluation at King's College, Cambridge." *Ecological solutions and evidence*, vol. 4, no. 2, Apr. 2023, doi: https://doi.org/10.1002/2688-8319.12243.

[3] N. Seitz, D. vanEngelsdorp, and S. D. Leonhardt. "Are native and non‐native pollinator friendly plants equally valuable for native wild bee communities?" *Ecology and Evolution*, vol. 10, no. 23, Oct. 2020, doi: https://doi.org/10.1002/ece3.6826.

[4] K. Berthon, F. Thomas, and S. Bekessy. "The role of 'nativeness' in urban greening to support animal biodiversity." *Landscape and Urban Planning*, vol. 205, no. 103959, p. 103959, Jan. 2021, doi: https://doi.org/10.1016/j.landurbplan.2020.103959.

[5] T. Amano, I. Butt, and K. S.-H. Peh. “The importance of green spaces to public health: a multi-continental analysis.” *Ecological Applications*, vol. 28, no. 6, pp. 1473–1480, 2018, Available: https://www.jstor.org/stable/26623246

[6] N. L. Smallwood and E. M. Wood. “The ecological role of native‐plant landscaping in residential yards to birds during the nonbreeding period.” *Ecosphere*, vol. 14, no. 1, Jan. 2023, doi: https://doi.org/10.1002/ecs2.4360.

[7] Arnaud Ameline, D. C. Thomas, C. Marion, D. Jean, and D. Guillaume. “How generalist insect herbivores respond to alien plants? the case of *Aphis fabae ‐ Myzus persicae ‐ Rhododendron ponticum.” Pest Management Science*, vol. 80, no. 4, Dec. 2023, doi: https://doi.org/10.1002/ps.7908.

[8] M. Masierowska. “Urban Bees Benefit from a Native Forest Species Grown in a City Environment–A Case Study of Geranium Phaeum L.” *Journal of Apicultural Science*, vol. 65, no. 2, pp. 331–343, Dec. 2021, doi: https://doi.org/10.2478/jas-2021-0024.

[9] R. J. Warren, S. Noezil, and C. Mokadam. “Non-native plants rarely provide suitable habitat for native gall-inducing species.” *Biodiversity and Conservation*, vol. 30, no. 10, pp. 2797–2805, Jun. 2021, doi: https://doi.org/10.1007/s10531-021-02222-7.

[10] A. Salisbury, J. Armitage, H. Bostock, J. Perry, M. Tatchell, and K. Thompson. “Enhancing gardens as habitats for flower-visiting aerial insects (pollinators): should we plant native or exotic species?” *Journal of Applied Ecology*, vol. 52, no. 5, pp. 1156–1164, Aug. 2015, doi: https://doi.org/10.1111/1365-2664.12499.

[11] F. Isbell *et al.* “Expert perspectives on global biodiversity loss and its drivers and impacts on people.” *Frontiers in Ecology and the Environment*, vol. 21, no. 2, Jul. 2022, doi: https://doi.org/10.1002/fee.2536.

[12] P. Kumar Rai and J. S. Singh. "Invasive alien plant species: Their impact on environment, ecosystem services and human health.” Ecological Indicators, vol. 111, no. 0, p. 106020, Apr. 2020, doi: https://doi.org/10.1016/j.ecolind.2019.106020.

Spectroscopic, Photometric, and Computational Analysis of B-Type Stars in M45: Gaia DR3 Radial Velocity Discrepancies

Timothy Winans, *Howard Community College, University of Maryland Baltimore County*
John Quach, *Howard Community College, University of Maryland Baltimore County*
Evan Reynolds, *Howard Community College*
Mentored by: Kenny A. Diaz Eguigure, M.S.

Abstract

Pleaides, or Messier 45 (M45) is a group of stars located in the constellation of Taurus. The scientific field of astronomy is primarily the observation and measurement of the electromagnetic spectrum (EMS) to obtain information about the intrinsic properties and evolutionary states of stars. For ground-based astronomy the only accessible portions of EMS are visible light which humans have evolved to sense such as the light on a computer screen, and the near-infrared. This research involved the collection of ground-based visible and near-infrared data on 9 bright "Naked eye" stars in M45. This involved the collection of spectroscopic data which is when the EMS is split into its constituent elements to determine the chemical information inside of the light. Photometric data is the measurement of the intensity or brightness of an objects EMS. Spectroscopic and photometric scientific data are represented through numerical values which can be further processed using advanced computational methods. 9 B-Type stars in M45 were targeted for ground-based spectroscopic and photometric observation. Spectral analysis at ≈ 4.2 × 10^2 nm – 7.4 × 10^2 nm indicated the presence of strong hydrogen Balmer absorption lines (Hα, Hβ, Hγ, Hδ) in observed line strengths and spectral slopes consistent with theoretical models and previous observations of early main sequence stars. Results of Isochrone fitting of M45 were consistent with contemporary stellar evolutionary models for B-type stars. GAIA DR3 data on the 9 B-Type stars was queried and calculated for comparison using Astropy and NumPy to derive stellar properties for 7 of the 9 targeted B-type stars. Discrepancies were observed between existing published radial velocities in SIMBAD for Merope (23 Tau) and Electra (17 Tau), and the calculated radial velocities derived from GAIA DR3 data.

Introduction

Galaxies have been observed since antiquity and cataloged since the late 17th century by a French astronomer and comet hunter named Charles Messier [1]. Messier catalogued objects that were fixed in the sky (including what we now know are galaxies nebulae and star clusters) to be avoided in the observations of comets. One of these was Messier 45 (M45) for short, also known as the Pleiades, and is a young bound open star cluster [2]. M45 has a long history in the study of stellar evolution, contributing to early observations that supported the empirical relationship between a star's temperature and luminosity [3]. This discovery revealed a pattern in which most stars fall along a sequence where hotter blue stars shine brighter, while cooler red stars are dimmer [4]. This enabled the classification of stars based on their evolutionary stage, which is termed as a spectral classification. This spectral classification encompasses O, B, A, F, G, K, M where O type stars are Blue and hottest (≈30,000-50,000 K) and M type stars are Red, and coolest (≈2,500-3,700 K). This is known as the Main Sequence (MS), MS stars consist of ≈ 90% of all stars in the observable universe [5].

MS stars undergo nuclear fusion in which hydrogen burns in the nuclear process of converting the hydrogen into helium in the stars' core. When the hydrogen is completely expended MS stars undergo diverging stellar evolution based on their solar mass which is an absolute value based on the mass of Earth's Sun which is 1 $M_\odot$ unit of solar mass. The larger the mass of a star the quicker it expends all its hydrogen. O and B type stars' lifespans can be only a few million years, whereas K and M type stars' lifespans are typically tens of billions to trillions of years. When B-type stars expend their hydrogen, their evolution diverges depending on their solar mass, if their solar mass is ≈ < 8-10 $M_\odot$ they typically explode as supernovae becoming either a neutron star, or a black hole. Lower-mass B-type stars ≈ > 8 $M_\odot$ may evolve into white dwarfs instead of undergoing core collapse, remaining on the MS along with F, G, K, and M type stars for billions to trillions of years. Comparatively, High-mass B-Type stars theoretically quickly evolve off the MS after undergoing gravitational collapse [6].

Uncertainties remain in the stellar evolution and formation of B-type stars in M45, such as their mass distribution, early evolution, and role in cluster dynamics. The observed mass segregation in the Pleiades challenges aspects of stellar formation models, such as whether massive stars migrate inward due to dynamical interactions or if they are formed in situ. Additionally, discrepancies in distance measurements from Hipparcos and GAIA have complicated efforts to refine stellar evolution tracks, which are needed to understand how B-Type stars transition off the MS [7]. Likewise, questions have been raised about the lack of expected lithium present in lower-mass M45 stars suggesting models of convective mixing may be incomplete [8]. This could have broader implications for nucleosyntheses, which is the process of stellar evolution in which remnants of stars that deplete their hydrogen eventually become other stellar objects [9].

By investigating stellar properties and formation histories of B-Type stars in M45, this research aims to address these gaps and refine our understanding of early stellar evolution in open clusters. To do this, we collected spectroscopy data for 9 B-type stars in M45, stellar properties can be determined by astronomical spectroscopy, in which light is dispersed into its

individual wavelengths to form a spectrum. This occurs when an electron absorbs a photon, gaining energy and transitioning to a higher energy level, called excitation, which creates absorption lines in the spectrum. When an electron transitions to a lower energy level, it emits a photon, producing an emission line in the spectrum, revealing a star's temperature, luminosity, mass, radial velocity, and composition. The current way to collect astronomical spectrographs are charge-coupled devices (CCDs). [10].

We analyzed data collected by GAIA, a European Space Agency astronomical observatory mission to make the most detailed and accurate 3-dimensional map of the Milky Way. As part of their mission to generate a three-dimensional map of stars, the European Space Agency's GAIA mapped motions, luminosity, temperature and composition. This effort has catalogued an unprecedented amount of baryonic matter and has produced an historic amount of data on stellar properties. Baryonic matter is all the matter in the universe that consists of protons, neutrons, and electrons. One aspect of GAIA data that requires further verification is the observation of bright B-type stars. Stellar brightness is known as magnitude, which is measured inversely where brighter objects have small or negative values and dimmer objects have larger values. The GAIA's data set is considered complete for fainter stars within the magnitude range of G = 12 to G =17, the dataset for brighter stars (G < 7) contains gaps and incomplete observations. This is attributed to the over-saturation of GAIA Charge-coupled device (CCD) detectors that were designed to be optimized for fainter harder to detect stars.

The goal of our research is to compare data collected from our survey of B-type stars from M-45 to the data collected from GAIA DR3 to model and to use the data to predict the stellar evolution of M45. Through the investigation of B-type stellar properties, we hope to better understand and predict their role in stellar evolution and formation processes in M45.

Methods

Target Selection

Nine B-type stellar members in M45 were selected for spectroscopic and photometric imaging. All the data from is from the GAIA DR3 dataset shown by the unique identifier, except for Alcyone (eta Tau) which has a unique GAIA DR2 identifier. The exclusion of Alcyone (eta Tau) from the GAIA DR3 data set was not known prior to observations being conducted. The target stars were selected based on their stellar proximity, apparent magnitude and spectral type. Consideration was given to stars that would have optimal placement in the sky during the observation periods to maximize visibility, minimize atmospheric interference, and ensure alignment with instrumental constraints. Consideration was given to factors including the targets' right ascension, declination, and altitude at the time of observation.

Observation Planning & Preliminary Procedures

After target selection, preliminary observation procedures that were conducted included assessing the equipment through initial observations and detailed analysis of equipment capabilities. Data gathering was limited to the correct combination of optimal sky conditions, weather conditions, and lunar phases. During preliminary observation sidereal times were calculated to track the rotation of the Earth relative to the stars. This is necessary to plan for the

optimal time in observing M45 during culmination, to reduce atmospheric distortion and maximize signal-to-noise ratio.

Observations were conducted on the nights of March 29, May 15, September 12, and October 10, 2024. The equipment used was a Sharpstar 150-28HNT Hyperbolic Newtonian Reflector, ZWO 1600mm Pro for the main camera, ZWO AM5 Harmonic for the mount, and an ASI Air Plus for the CPU. The telescope configuration of the Sharpstar 150-28HNT Hyperbolic Newtonian Reflector had an f/stop of f/2.8, and the Shelyak Star Analyzer (SA) 200 for the spectrograph. The SA-200 transmission grating has 2.0×10^2 lines/mm in a close-coupled optical configuration which can provide high spectral resolution with minimal system errors. This configuration enables the observation of spectra in the visible to near-infrared range between
$4.2^3 \times 10$ Å $- 7.4 \times 10^3$ Å *or converted nanometers* $4.2\ x\ 10^2\ nm$ – $7.4\ x\ 10^2\ nm$. The main camera was cooled to –20 degrees Celsius and had a gain of 139.

The observatory used in this study (referred to as the HCC rooftop laboratory) is located on the roof of Howard Community College's Science, Engineering, and Technology (SET) building. The sky surrounding Howard Community College (HCC) typically measures class 7 on the Bortle scale, which is indicative of high light pollution (Monterroza, et al, 2024). To test the calibration and data quality of the spectrographic imaging. The star Regulus (alf Leo) was targeted on May 5th, 2024, at the HCC rooftop observatory. The cropped spectra of Regulus is shown in (Figure 1), and its spectra was analyzed using R-SPEC software shown in (Figure 2).

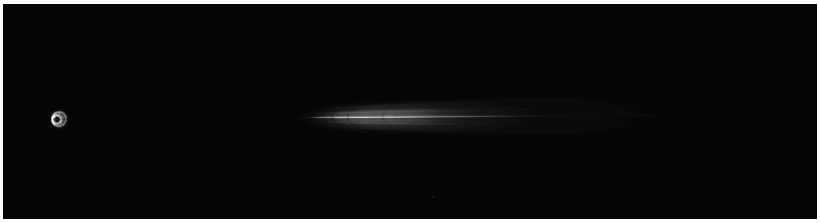


Figure 1: Cropped Regulus Spectra (May 5th, 2024)

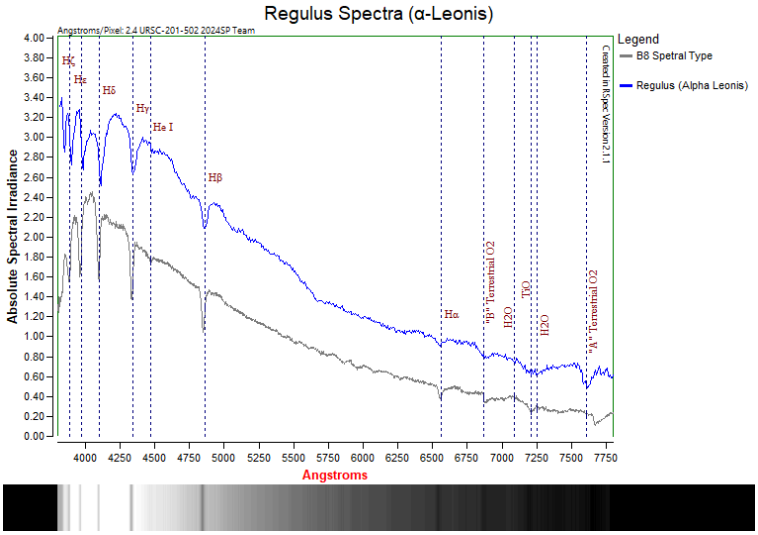


Figure 2: Regulus Spectrum (Blue), B8 Spectral type model (Gray).

Clear and sharp Balmer lines in Regulus's spectrum were observed shown as the blue line representing our collected data in (Fig. 2), indicative of high-resolution spectra data. This includes the presence of Hydrogen beta (Hβ) at ≈ 4861 Å presenting as a well-defined dip with clear line wings. The presence of Hydrogen alpha (Hγ) at ≈ 4341 Å also presents as a sharp and distinct dip in Regulus's spectra data. The observation of the alignment of spectral features Hβ, Hγ, Hδ to their expected position in Å provided evidence of wavelength calibration [11]. Close alignment with the B8 reference spectrum indicated the absence of any obvious instrumental or processing artifacts was noted, along with the close alignment with the B8 reference spectrum [12]. This close alignment between observational collected data (Blue) and reference data (Gray) of Regulus is consistent with its classification as a B-8 star. The observed line profiles show relatively narrow wings which are consistent with the expected rotation and temperature of a B8 star. No excessive broadening is visible in the spectrum, which indicates instrumental effects such as slit or detecting broadening are minimal [13].

Raw Spectra Image Processing

The raw spectra images were cropped and manually rotated using the GNU Image Manipulation Program (GIMP) an open-source program similar to Adobe Photoshop, and Windows photos [14]. This was conducted to resolve the individual spectra of each star for detailed analysis illustrated shown in (Fig. 1).

Figure 3: Non-Cropped Spectra of M45 Fall 2024

R-SPEC Software

R-Spec Software developed by Field Tested Systems LLC was used to process the spectroscopy data. The spectra images are loaded into R-SPEC, the background noise is

subtracted, and the data is calibrated from pixels to angstroms. The spectrum is then cut to exclude all data between 4000 < Å and < 7500 Å, which removes data not within the visible to near-infrared range. Further processing was done for instrument response calibration through the creation of an R-SPEC Dat file. The data is then divided by the instrument calibration Dat file using the R-SPEC Math on 2 series, which yields the final calibrated spectra data as shown in (Fig. 2) [15].

Astropy GAIA query and NumPy Calculations

Astropy is a widely used open-source astronomy and scientific computing program that runs on the Python programming language [16]. NumPy is an array programming library that runs on the Python programming language and allows complex mathematical operations to be performed on data. The use of Astronomical Data Query Language (ADQL) with Astroquery which is part of the Astropy software ecosystem allows the direct retrieval of data from the GAIA Data Processing and Analysis Consortium (DPAC) [17].

Blind Astrometric Calibration

Observational targets were confirmed using blind astrometric plate solving through the uploading of images to astrometry.net without providing it with any additional reference [18]. The results showed all 9 targets were in the telescope's field of view. An anomaly appeared in our images that we were able to characterize and eliminate from our data. Using ImageJ software to analyze the pixels it was determined it was likely an imaging artifact.

Results

B6 spectral type

The spectra of targeted B6 stars Electra (17 Tau), Merope (23 Tau), and Taygeta (q Tau) were captured on two separate observation sessions (Figs. 4 and 5). In both observational data sets Electra, Merope, and Taygete display absorption lines from the Hydrogen Balmer series, including Hβ and Hγ dips. This is consistent with their classification as B6 stars, displaying an expected gradual decrease in relative flux, a measure of the intensity of light from an astronomical object compared to a reference value, which was observed towards shorter wavelengths in the blue part of the spectrum [19]. The Hydrogen alpha (Hα) features in the second observation display broader features, which appear to be weaker absorption features than the first observation. It is possible this difference was due to minor variations in the stellar atmosphere, observational circumstance changes such as temperature changes, atmospheric disturbances, minor shift in resolution or equipment.

Line broadening is present in both observations, which is consistent with rapid rotation. However, slight differences can be seen between the first and second session which could have resulted from possible slight differences in reduction methods or instrumental effects. The similarities in the observed spectra between Electra, Merope, and Taygeta are consistent with their membership in the same cluster and their B6 spectral type. Possible variations in the flux calibration or atmospheric correction between the first and second session could be a possible cause of differences in the observing sessions.

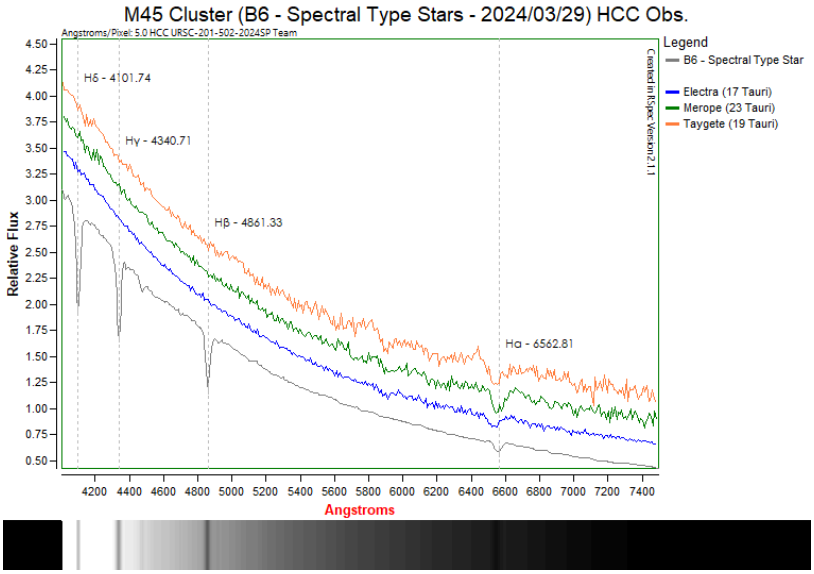


Figure 4: M45 Cluster B6 - Spectral Type Stars 1st Observation

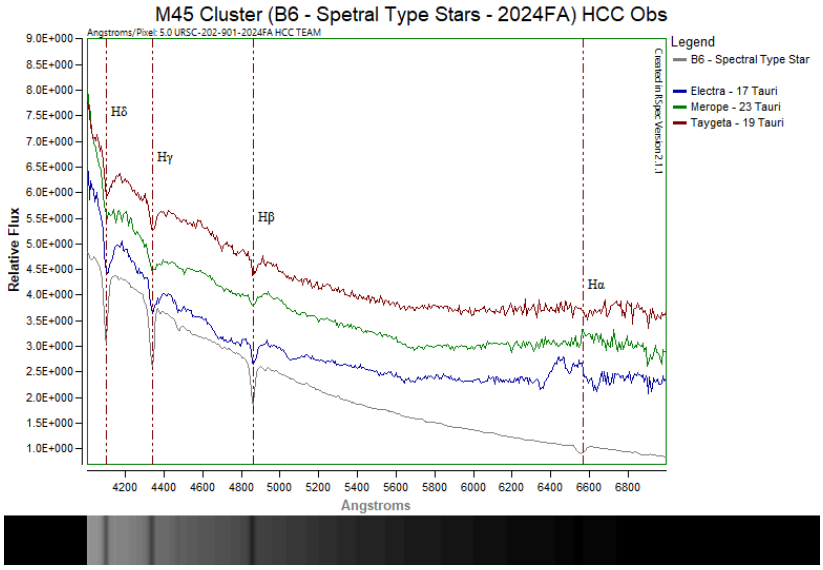


Figure 5: M45 Cluster B6-Spectral Type Stars 2nd Observation

B7 Spectral Type

The spectra of the targeted B7 stars Alcyone (eta Tau, Maia (20 Tau), and Celaeno (16 Tau) were captured on two separate observation sessions shown in (Fig. 6) and (Fig 7.). In both observational data sets Alcyone, Maia, and Celaeno present prominent Balmer series absorption lines Hα at ≈ 6562.81 Å, Hβ at ≈ 4340.71 Å, Hγ at ≈ 4340.71 Å. This is consistent with their classification as B7 spectral type stars. The relative depth and positioning, which is the intensity of the spectral lines compared to a baseline or continuum level, are consistent between both sessions which is expected of stars of similar temperature and composition. The spectra in both observations display a continuum with higher flux levels in the blue shorter wavelength regions of the spectrum, gradually decreasing towards the red end of spectrum. This is consistent with

the higher surface temperatures of B7 stars; further validated by the observed effective temperature of Celaeno (16 Tau) from GAIA spectrophotometry of 1.16E+04 which is a surface temperature of ≈ 11,600 K [20].

The second session shows evidence of a slightly noisier baseline and broader scatter in the flux, especially in the continuum. Possible causes could be differences in atmospheric conditions, instrumental sensitivity, or possible calibration inconsistencies between the two observations. The second session presents a noticeable rise in flux in the red region of the spectrum < 6500 Å, this could possibly be due to differences in how the SA 200 spectrograph handled background subtraction or calibration in the second observation. The flux ranges in the second observation also appear to be lower overall, which could indicate differences in normalization or variations in observational sensitivity such as telescope settings or sky transparency. The second observation captured slightly broader absorption lines which could indicate lower spectral resolution or broader instrumental response during the second observation. Contributing factors could be instrumental variability between the sessions, atmospheric conditions, calibration issues, exposure time or signal-to-noise ratio.

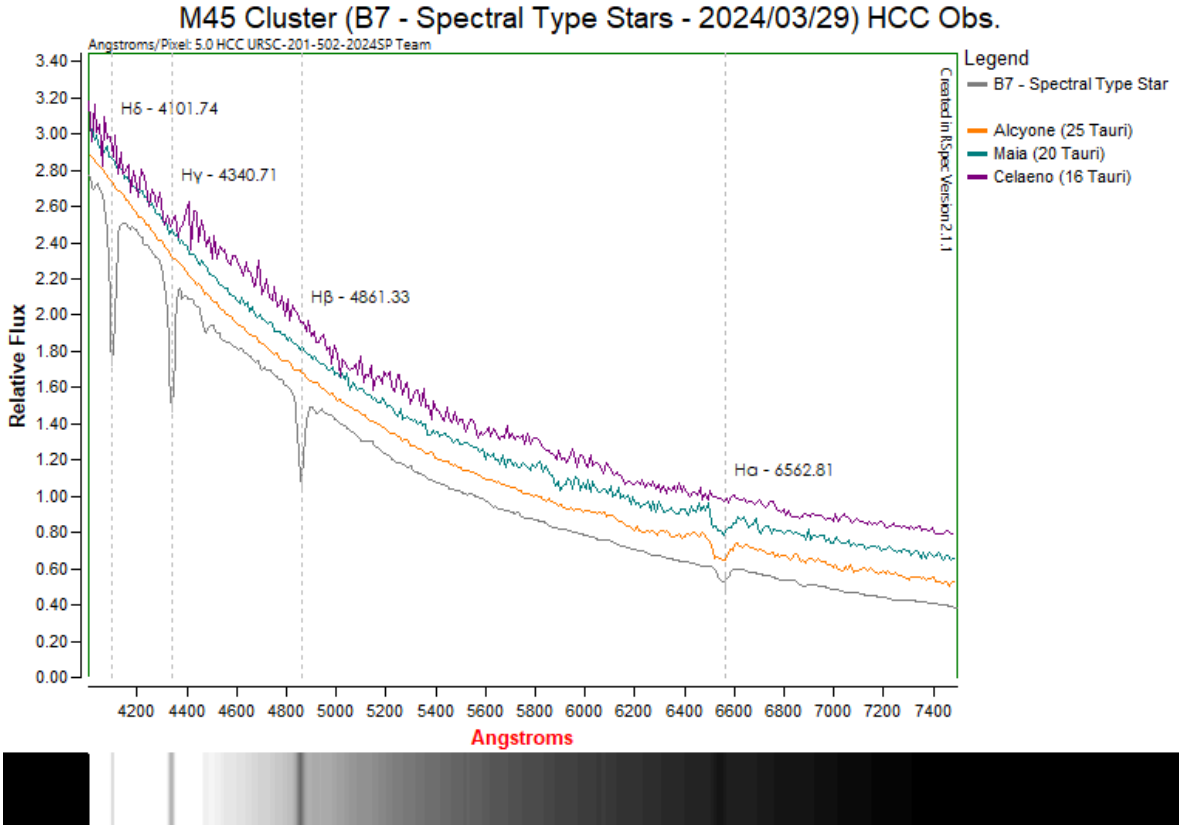


Figure 6: M45 Cluster B7 Spectral Type Stars 1st Observation

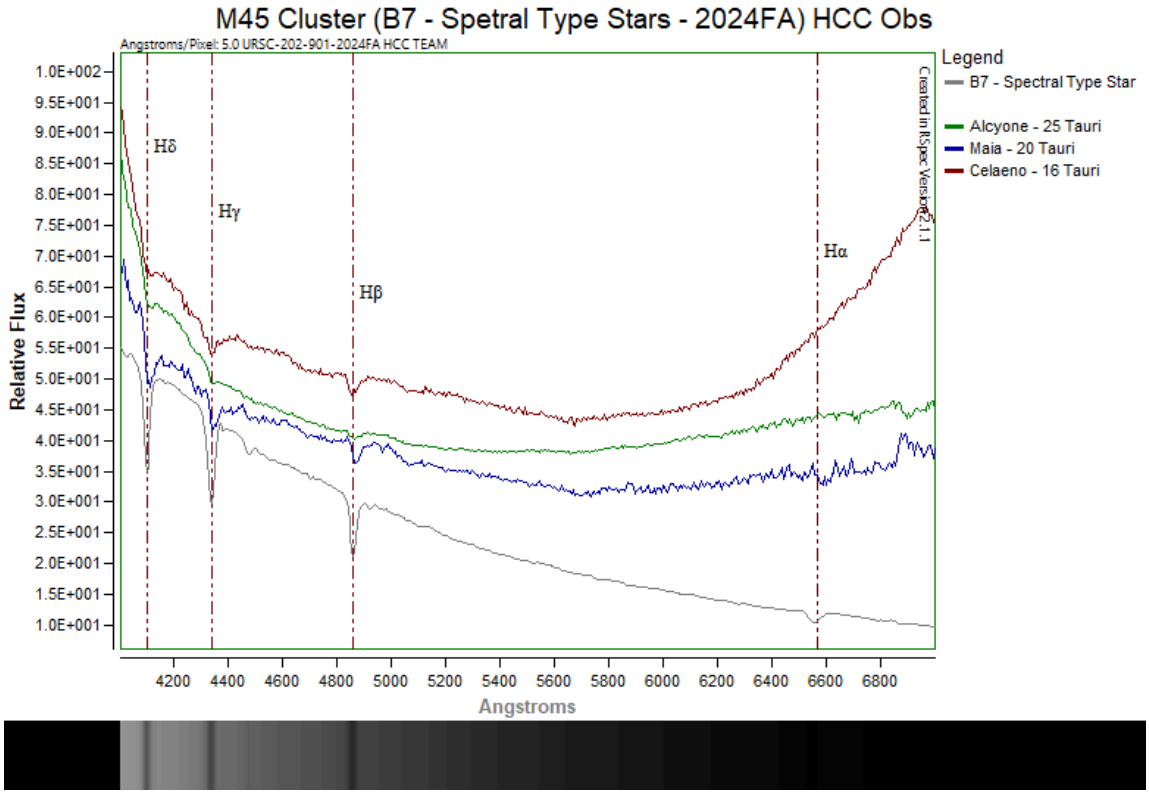


Figure 7: M45 Cluster B7 Spectral Type Stars 2nd Observation

B8 spectral type

The spectra of the targeted B8 stars Atlas (27 Tau), Asterope (21 tau), and Pleione (28 Tau) were captured on two separate observation sessions shown in (Fig. 8) and (Fig. 9). Both observational data sets show prominent Balmer series absorption lines Hα at ≈ 6562.81, Hγ ≈ 4340.71 Å, Hδ at 4101.74 Å which is consistent with B8 stars. The relative positions and depths of the lines remain stable between the two observations. Both observations present a continuum with higher flux in the blue shorter wavelengths that gradually decreases towards the red of the spectrum which is consistent with the high temperatures of B8 stars. The spectral profiles exhibit nearly identical line depths and profiles between the observing sessions, minor variations in continuum flux are within the expected range for observational conditions further supporting the consistency of the spectral characteristics across both sessions. The consistency and robustness of the Balmer absorption lines across both observations confirms Atlas (27 Tau), Asterope (21 tau), and Pleione (28 Tau)'s B8 classification, and presents reliable data for determining properties such as temperature and pressure.

The second observation exhibits smoother flux transitions between ≈ 4800-5000, where the continuum appears more uniform compared to the first session. However, at shorter wavelengths ≈ 4100 Å near Hδ increased noise is present. In the second observation an elevation in flux is observed beyond 6500 Å at the red end of the spectrum. This could be due to calibration discrepancies, background light contamination, or instrument variability. The first observation has relatively consistent noise levels across the spectrum. The second observation displays greater noise variability particularly in the lower flux regions. The absorption lines in

the second observation are slightly broader and less distinct than the first observation. This could be due to lower spectral resolution, instrument broadening, atmospheric conditions, detector efficiency, slit alignment, flux normalization, background subtraction technique, exposure times, signal-to-noise rations during the second observation.

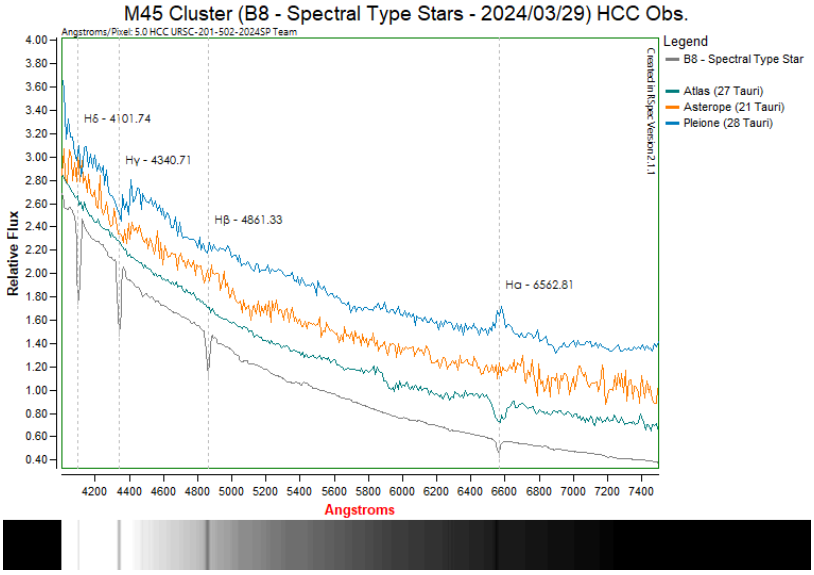


Figure 8: M45 Cluster B8 Spectral Type Stars Observation 1

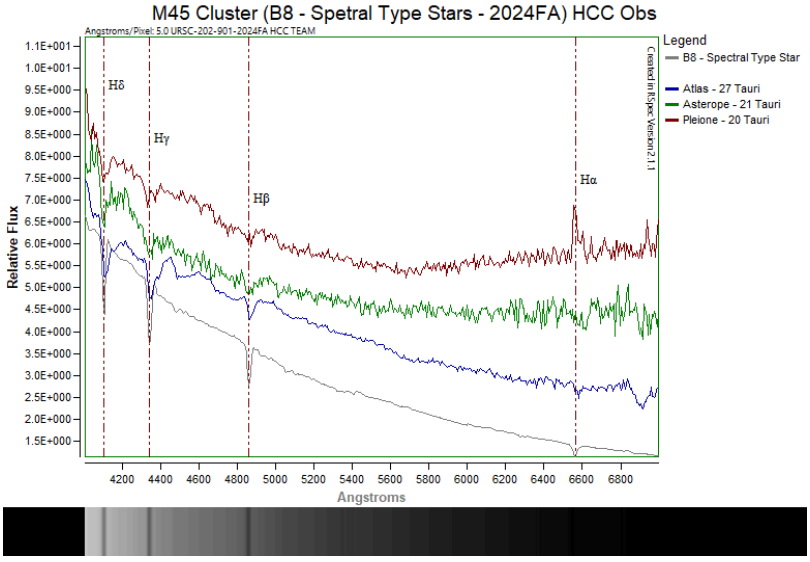


Figure 9: M45 Cluster B8 Spectral Type Stars Observation 2

M45 GAIA Isochrone B-Type Modelling

GAIA DR3 was queried and aggregated to plot a theoretical isochrone curve for M45 shown in (Fig. 10). A theoretical isochrone curve is a model-generated plot that represents the evolutionary state of a population of stars of the same age but different masses. This is used to determine age, metallicity and composition, and distance, qualitative analysis was performed to compare observational data collected and theoretical modelling.

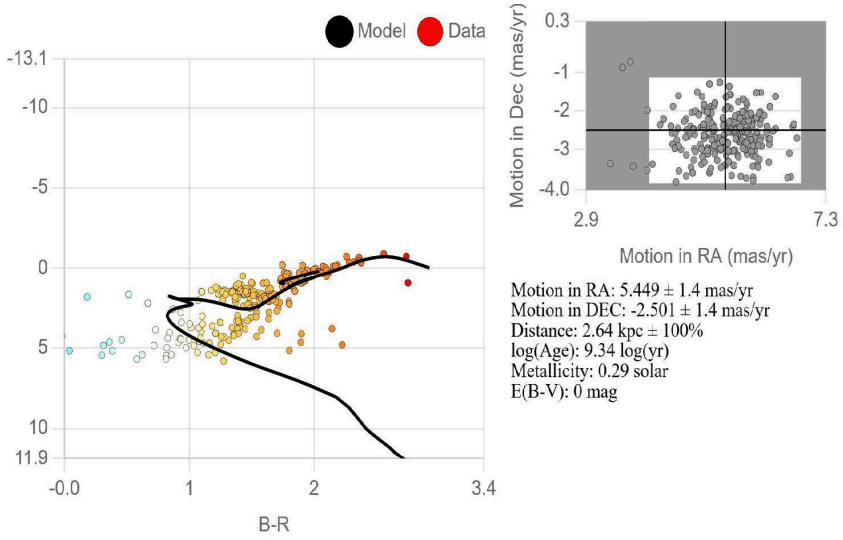


Figure 10: GAIA derived M45 Isochrone Model

The theoretical isochrone model is consistent with previous data about the cosmological age of M45, although presented as slightly older at ~220 million years (Myr) than the current accepted ~100-150 Myr [21]. The Isochrone curve and fitting indicates evidence of a young open-cluster with a statistically significant population in the early-mid MS life stage [22]. The hot (blue) B-type members on the isochrone model in Figure 7 present as a statistical outlier on the isochrone curve, not aligning with the theoretical isochrone fitting [23]. Our findings are consistent with the lack of viable GAIA DR2 and DR3 data of high magnitude stars, as mentioned previously due to over-saturation of GAIA CCD detectors. This effect is especially pronounced to the B7-B8 spectral class of stars, evidenced by the complete exclusion of Alcyone in the GAIA DR3 dataset despite its inclusion in the GAIA DR2 dataset.

The theoretical isochrone models predicted proper motion Right Ascension (RA) which can be thought as the celestial longitude, and $5.449 \pm 1.4\, mas/yr$ Declination (DEC) which can be thought of as the celestial latitude motion $-\ 2.501 \pm 1.4\, mas/yr$ differs significantly from observed proper motion $50.10 \pm 0.74\, mas/yr$. The observation data likely reflects individual stellar motions within M45, observed motion variation is $\sigma = 0.74\, mas/yr$ indicative of stars with very similar motion expected of cluster members. The Model-predicted motion does not match the mean observed proper motion, low-scatter in the observed data values is suggestive of a coherent moving group of stellar members.

Astropy GAIA Calculations

The Astropy GAIA Python workflow referenced in the methods section was used by the authors to calculate ≈ 161 different astronomical data points from 6 out of the 9 targeted stars [24]. This research used GAIA DR3 astrometric and photometric data to computationally analyze the galactic dynamics of these stars which can be referenced in full in the Supplemental Data. The data queried for this research using ADQL directly from GAIA DR3 included ≈ 83 different data points which can be seen in the Virtual Observatory Table (VOT) file in the author's supplemental data. These ≈ 83 GAIA DR3 points included only RA, DEC, Proper Motion in Declination (PMDEC), Proper Motion in Right Ascension, Radial velocities for 3 out of 6 stars, Parallax and parallax error. Photometric mean magnitudes for G, BP, and RP band, and effective temperature (TEFF) for 3 out of 6 stars. The data in tables 1-6 was selected due to importance in galactic dynamics, and due to space constraints in the display of tabular data.

Electra (17 Tau) Gaia DR3 65271996684817280	
Distance (pc)	*1.20E+02*
Proper Motion (mas/yr)	*5.05E+01*
Absolute Magnitude (G)	*-1.69E+00*
Luminosity (L/Lsun)	*4.07E+02*
Color Index (Bp-Rp)	*-8.80E-02*

***Table 1**: Electra (17 Tau) Gaia DR3 65271996684817280*

Maia (20 Tau) Gaia DR3 65283232316451328	
Distance (pc)	*1.30E+02*
Proper Motion (mas/yr)	*4.95E+01*
Absolute Magnitude (G)	*-1.71E+00*
Luminosity (L/Lsun)	*4.14E+02*
Color Index (Bp-Rp)	*-1.38E-02*

***Table 2**: Maia (20 Tau) Gaia DR3 65283232316451328*

Taygeta (q Tau) Gaia DR3 65296907494549120	
Distance (pc)	*1.05E+02*
Proper Motion (mas/yr)	*4.99E+01*
Absolute Magnitude (G)	*-8.40E-01*
Luminosity (L/Lsun)	*1.85E+02*
Color Index (Bp-Rp)	*-1.07E-01*

***Table 3**: Taygeta (q Tau) Gaia DR3 65296907494549120*

Pleione (28 Tau) Gaia DR3 66529975427235712	
Distance (pc)	*1.38E+02*
Proper Motion (mas/yr)	*5.15E+01*
Absolute Magnitude (G)	*-4.98E-01*
Luminosity (L/Lsun)	*1.35E+02*
Color Index (Bp-Rp)	*-3.31E-02*

***Table 4**: Pleione (28 Tau) Gaia DR3 66529975427235712*

Celaeno (16 Tau) Gaia DR3 65287458566524928	
Distance (pc)	*1.35E+02*
Proper Motion (mas/yr)	*4.92E+01*
Absolute Magnitude (G)	*-2.17E-01*
Luminosity (L/Lsun)	*1.04E+02*
Color Index (Bp-Rp)	*-2.12E-02*

***Table 5**: Celaeno (16 Tau) Gaia DR3 65287458566524928*

Atlas (27 Tau) Gaia DR3 66526127137440128	
Distance (pc)	*1.23E+02*
Proper Motion (mas/yr)	*5.00E+01*
Absolute Magnitude (G)	*-1.84E+00*
Luminosity (L/Lsun)	*4.64E+02*
Color Index (Bp-Rp)	*-3.64E-02*

***Table 6**: Atlas (27 Tau) Gaia DR3 66526127137440128*

Electra (17 Tau) results on distance and proper motion agree with published results on SIMBAD, derived luminosity of 407 L⊙, and the Color Index (Bp-Rp) of -8.80E-02 is consistent for a B6IIe star [25]. Maia (20 Tau) results on distance and proper motion agree with published results in SIMBAD, the derived luminosity of 414 L⊙, and Color Index (Bp-Rp) of -1.38E-02 is consistent for a B7III star. Taygeta (q Tau) results on distance and proper motion agree with published results on SIMBAD, derived luminosity of 185 L⊙, and Color Index (Bp-Rp) of -1.07E-01 is consistent for a B6IV star. Atlas (27 Tau) results on distance and proper motion agree with published results on SIMBAD, derived luminosity of 464 L⊙, and Color Index (Bp-Rp) -3.64E-02 is consistent for a B8III evolving off the MS.

Celaeno (16 Tau) Gaia DR3 65287458566524928 results on distance and proper motion agree with published results on SIMBAD. The derived luminosity of 104 L⊙, and Color Index (Bp-Rp) of -2.12E-02 is consistent for a B7V star. Pleione (28 Tau) Gaia DR3 66529975427235712 results on distance and proper motion agree with published results on SIMBAD, derived luminosity of 104 L⊙, and the Color Index (Bp-Rp) of -3.31E-02 is inconsistent for a B8Vne star. Given that Celaeno is a B7V star with a derived luminosity of 104 L⊙. The photometric variability of Pleione is well documented in the literature by Tanaka and et al [26], Nemravová and et al [27], Marr and et al [28]. This variability is currently theorized to be attributed to Pleione's rapid rotation, and a broken BE star disc. The photometric variability observed by Pleione is consistent with previous observations, the exact nature of this observed variability is however beyond the scope of this paper.

Parallax Over Error

Electra (17 Tau) Gaia DR3 65271996684817280 has a published Parallax (mas) of 8.3457. The parallax derived through Astropy is 8.35E+00 mas with parallax over error of 1.90E+01 which is 19.0. Parallax over error < 5.0 has been considered reliable [28]. 6 out of 9 stars observed have parallax over errors indicating high certainty shown in (table 7).

	17 Tau	20 Tau	28 Tau	16 Tau	q Tau	27 Tau
Parallax (mas)	8.35	7.67	7.24	7.39	9.54	8.12
Parallax Error (mas)	0.439	0.310	0.125	0.072	0.403	0.479
Parallax Over Error	19.0	24.7	57.7	102.0	23.7	16.9

***Table** 7: Parallax, Parallax Error, and Parallax Over Error*

Radial Velocity SIMBAD Discrepancies

The star Merope (23 Tau) Gaia DR3 65205373152172032 has published radial velocity on SIMBAD as 6.2 ± 2.0 (km/s) derived from Wilson (1956), the following radial velocity was calculated through this study for Merope (23 Tau) 4.80E+00 (km/s) [29]. For the star Electra (17 Tau) Gaia DR3 65271996684817280 the published radial velocity on SIMBAD is 6.87 ± 0.72 (km/s) from Torres (2021) [30]. The following radial velocity for Electra (17 Tau) was calculated through this study 4.76E+00 (km/s).

21 & 22 Tau Double Star System Photometrically Resolved

The double star system 21 & 22 Tau was photometrically resolved in our imaging data. The separation between the members is evident in the photometric measurements and is clearly distinguishable in the astrometric solution processed image shown in (Fig. 11).

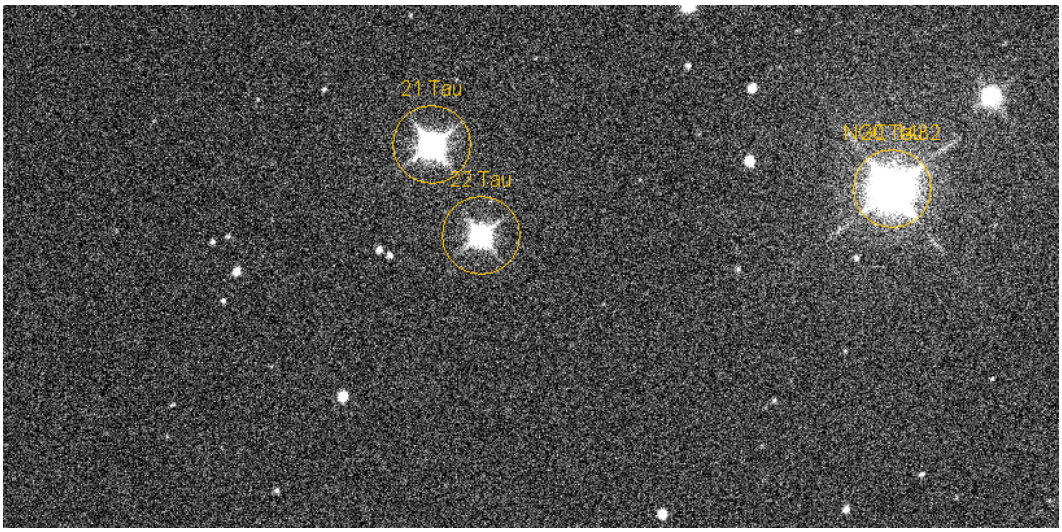


Figure 11: *21 & 22 Tau Double Star System*

Discussion

The results of the spectroscopy observations are strong evidence in support of the existing spectral types of the observed B6, B7, and B8 star classifications. The consistency and robustness of Balmer absorption lines across both observation sessions for the B8 stars could possibly provide data to better determine physical properties such as temperature and pressure. Through the measurement of depth and equivalent width (EW) of the Balmer absorption lines, with measurement of line broadening, and effective temperature. EW is a measure used in spectroscopy to quantify the strength of an absorption or emission line in a spectrum that would represent the width of a hypothetical triangular feature. Likewise, pressure and surface gravity could be modelled from the Balmer line wings using stellar atmosphere codes or synthetic spectrum fitting.

The theoretical isochrone models predicted proper motion differing significantly from observed proper motion. The Isochrone curve and fitting provided clear evidence of a young open-cluster with a statistically significant population of stars in the early-mid MS life stage which is consistent with previous observations of M45. However, the model is presenting as slightly older at ~220 Myr than the current accepted ~100-150 Myr. Further modeling and observation of B-type stars in M45 should be conducted to verify effects on cosmological modelling. The authors cannot state with a high degree of confidence whether the isochrone modelling is consistent with the stellar evolution of M45.

Differences in the continuum shape and flux scaling between the first and second observation session may require correction or additional cross-referencing with standard stars or

reference spectra. Observed variations in noise and line resolution suggest that additional sessions or increased standardization across observations may be needed to improve data reliability. Additionally, variations in the red wavelength through elevated red flux in the second session may require additional investigation to ensure accurate flux calibration and data consistency for future investigations. A comparison of the observed and expected wavelengths for the Balmer series (Hα, Hγ, Hδ) was conducted on the B6, B7, and B8 spectral type stars. The relative difference between observed and actual values was computed using the following equation:

$$L_m = \frac{\lambda_{obs} - \lambda_{act}}{\lambda_{act}}$$

where λ_{obs} is the measured wavelength and λ_{act} is the theoretical laboratory wavelength.

The computed L_m values for all spectral lines were found to be on order of 10^{-4}-10^{-6}, indicating only minor deviations from the expected wavelengths. This suggests that instrumental calibration was well-maintained, and that no significant systematic errors occurred affecting the wavelength measurements. Furthermore, no strong trends in redshift or blueshift were detected across all spectral types. The observed variations could be attributed to instrumental precision limitations stemming from spectrograph calibration drift. Atmospheric effects could have introduced shifts due to the ground-based nature of the observations. The variation could be attributed to Intrinsic stellar motion; however, the small magnitude of the computed L_m values suggest this effect is negligible.

The GAIA Python workflow calculations further provided evidence in support of the current spectral classifications of the 7 stars. Through the consistency of results on distance and proper motion with published results on SIMBAD. The luminosity in L⊙ and the Color Index (Bp-Rp) for all 7 stars were calculated and the results appeared consistent with the spectral classification of all 7 stars. Inconsistencies in the observed photometric properties of Pleione were found in our derived luminosity of 104 L⊙, and the Color Index (Bp-Rp) of -3.31E-02 which is inconsistent for a B8Vne star providing further evidence of its variability. However, the exact causes of Pleione's variability are outside of the scope of this research and should be explored further. Furthermore, 6 out of 9 stars observed have parallax over errors indicating high certainty. This research also used Large Language Models Primarily Chat-GPT release 4o to supplement the completion of certain backend tasks such as data analysis and coding.

The calculated radial velocities for Merope (23 Tau) Gaia DR3 65205373152172032 and Electra (17 Tau) Gaia DR3 65271996684817280 differ significantly from previous observations. The age of the observation by Wilson is significant, however the observation by Torres is relatively recent. The following radial velocity was calculated for Merope (23 Tau) Gaia DR3 65205373152172032 to be 4.80 (km/s). The following radial velocity for Electra (17 Tau) Gaia DR3 65271996684817280 was calculated to be 4.76 (km/s).

Conclusion

Given the consistency of the spectroscopy results across the B6, B7, and B8 spectral types, it is concluded that the observed spectral line positions are reliable and do not indicate any significant radial velocity shifts for the 9 observed stars in M45. Future work may involve higher spectral resolution observations, and a broader sample to further confirm these findings. As seasonal weather conditions did not allow observations to be conducted within a close enough window, future observations should aim to conduct the observations in short succession. The following improved radial velocities were calculated for Merope (23 Tau) Gaia DR3 65205373152172032 at 4.80E+00 (km/s) and Electra (17 Tau) Gaia DR3 65271996684817280 at 4.76E+00 (km/s). The theoretical isochrone model predicted proper motion differed significantly from observed proper motions, Astropy and NumPy calculations are consistent with previous observational data.

Acknowledgements

This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

This research has made use of the SIMBAD database, operated at the Centre de Données astronomiques de Strasbourg (CDS), Strasbourg, France.

This research made use of R-SPEC software developed by Field Tested Systems LLC
The authors would like to acknowledge the assistance and guidance from previous Howard Community College URSC researchers Anjolie Tuazon, Micaela Deugarte, and Valeria Monterroza.

The authors would also like to acknowledge assistance provided by Dr. Brendan Diamond of the Howard Community College URSC program.

Contact: timothy.winans@howardcc.edu, twinans1@umbc.edu, timothyrwinans@gmail.com

---

References

[1] Sparavigna, A., “The Pleiades: the celestial herd of ancient timekeepers”, *arXiv e-prints*, Art. no. arXiv:0810.1592, 2008. https://doi.org/10.48550/arXiv.0810.1592

[2] C. Messier “Connaissance des Temps”, (Paris, 1784).

[3] Rosenberg, H. “Über den Zusammenhang von Helligkeit und Spektraltypus in den Plejaden”, *Astronomische Nachrichten*, vol.186, no.5, pp.71-78, 1910

[4] Russell, H. N., “Relations Between the Spectra and Other Characteristics of the Stars”, Popular Astronomy, vol. 22, pp. 275–294, 1914. https://ui.adsabs.harvard.edu/abs/1914PA.....22..331R/abstract

[5] Kippenhahn, R. and Weigert, A., Stellar Structure and Evolution. 1990, p. 192. https://ui.adsabs.harvard.edu/abs/1990sse..book.....K/abstract

[6] T. Constantino, I. Baraffe, T. Goffrey, J. Pratt, T. Guillet, D. G. Vlaykov, and L. Amard, "Suppression of lithium depletion in young low-mass stars from fast rotation," *Astronomy & Astrophysics*, vol. 654, p. A146, 2021. [Online]. https://doi.org/10.1051/0004-6361/202141402.

[7] Melis, C., Reid, M. J., Mioduszewski, A. J., Stauffer, J. R., and Bower, G. C., “A VLBI resolution of the Pleiades distance controversy”, Science, vol. 345, no. 6200, pp. 1029–1032, 2014. https://ui.adsabs.harvard.edu/link_gateway/2014Sci...345.1029M/doi:10.1126/science.1256101

[8] Schwarzschild, M., Structure and evolution of the stars. . 1958. http://www.jstor.org/stable/j.ctt183pq2p

[9] W. S. Boyle and G. E. Smith, "Charge coupled semiconductor devices", in The Bell System Technical Journal, vol. 49, no. 4, pp. 587-593, April 1970, https://doi.org/10.1002/j.1538-7305.1970.tb01790.x

[10] Dodd, W., “What is Sidereal Time and What Is It Good For?”, Journal of the Royal Astronomical Society of Canada, vol. 97, no. 6, p. 278, 2003. https://articles.adsabs.harvard.edu/pdf/2003JRASC..97..278D

[11] Labiano, A, et al, “Wavelength calibration and resolving power of the JWST MIRI Medium Resolution Spectrometer”, Astron. Astrophys. Vol. 656, pp. 1-14, 2021, https://ui.adsabs.harvard.edu/link_gateway/2021A&A...656A..57L/doi:10.1051/0004-6361/202140614

[12] Baum, S. et al., 1996, “STIS Instrument Handbook”, Version 1.0 (Baltimore: STScI). https://www.eso.org/~amicol/HST/stis_ihb_all.pdf

[13] B. W. Carroll and D. A. Ostlie, An Introduction to Modern Astrophysics, 2nd ed. Cambridge, UK: Cambridge University Press, 2017. https://doi.org/10.1017/9781108380980

[14] GIMP Development Team, GIMP: GNU Image Manipulation Program, Version 2.10, GIMP.org, 2025. [Software]

[15] Field, T., “A Survey of Current Amateur Spectroscopic Activies, Capabilities and Tools”, Society for Astronomical Sciences Annual Symposium, vol. 33, pp. 131–138, 2014. https://ui.adsabs.harvard.edu/abs/2014SASS...33..131F/abstract

[16] Astropy Collaboration, “The Astropy Project: Sustaining and Growing a Community-oriented Open-source Project and the Latest Major Release (v5.0) of the Core Package”, The Astrophysical Journal, vol. 935, no. 2, Art. no. 167, IOP, 2022. https://ui.adsabs.harvard.edu/link_gateway/2022ApJ...935..167A/doi:10.3847/1538-4357/ac7c74

[17] Astroquery Development Team, Astroquery: Python tools for querying astronomical databases, Documentation, [Online]. Available: https://astroquery.readthedocs.io/en/latest/.

[18] Lang, D. W. Hogg, K. Mierle, M. Blanton, and S. Roweis, "Astrometry.net: Blind astrometric calibration of arbitrary astronomical images," Astronomical Journal, vol. 139, no. 5, pp. 1782-1795, Mar. 2010, http://dx.doi.org/10.1088/0004-6256/139/5/1782

[19] Kinney, A. L., Bohlin, R. C., Calzetti, D., Panagia, N., and Wyse, R. F. G., “An Atlas of Ultraviolet Spectra of Star-forming Galaxies”, The Astrophysical Journal Supplement Series, vol. 86, IOP, p. 5, 1993. https://ui.adsabs.harvard.edu/link_gateway/1993ApJS...86....5K/doi:10.1086/191771

[20] Gaia Collaboration, A. Vallenari, A. G. A. Brown, T. Prusti, J. H. J. de Bruijne, F. Arenou, C. Babusiaux, et al., "Gaia Data Release 3: Summary of the Content and Survey Properties," Astronomy & Astrophysics, vol. 674, Art. no. A1, June 2023, https://doi.org/10.1051/0004-6361/202243940

[21] S. Gossage, C. Conroy, A. Dotter, J. Choi, P. Rosenfield, P. Cargile, and A. Dolphin, "Age Determinations of the Hyades, Praesepe, and Pleiades via MESA Models with Rotation," The Astrophysical Journal, vol. 863, no. 1, p. 67, Aug. 2018, https://doi.org/10.3847/1538-4357/aad0a0

[22] Fritzewski, D. J., Barnes, S. A., James, D. J., and Strassmeier, K. G., “The rotation period distribution of the rich Pleiades-age southern open cluster NGC 2516. Existence of a representative zero-age main sequence distribution”, Astronomy and Astrophysics, vol. 641, Art. no. A51, 2020. https://doi.org/10.1051/0004-6361/201936860

[23] Hazlehurst, J. and Thomas, H.-C., “Stellar rotation and the age of the Pleiades.”, Monthly Notices of the Royal Astronomical Society, vol. 150, OUP, p. 311, 1970. https://ui.adsabs.harvard.edu/link_gateway/1970MNRAS.150..311H/doi:10.1093/mnras/150.3.311

[24] C. R. Harris, K. J. Millman, S. J. van der Walt, et al., “Array programming with NumPy,” Nature, vol. 585, pp. 357–362, Sep. 2020. https://doi.org/10.1038/s41586-020-2649-2

[25] Wenger, M., et al, “The SIMBAD astronomical database. The CDS reference database for astronomical objects”, Astronomy and Astrophysics Supplement Series, vol. 143, pp. 9–22, 2000. https://ui.adsabs.harvard.edu/link_gateway/2000A&AS..143....9W/doi:10.1051/aas:2000332

[26] K. Tanaka, K. Sadakane, S. Narusawa, H. Naito, E. Kambe, J. Katahira, and R. Hirata, "Dramatic Spectral and Photometric Changes of Pleione (28 Tau) between 2005 November and 2007 April," Publ. Astron. Soc. Jpn., vol. 59, no. 4, pp. L35–L39, Aug. 2007, https://doi.org/10.1093/pasj/59.4.L35

[27] Nemravová, J., “Properties and nature of Be stars. 27. Orbital and recent long-term variations of the Pleiades Be star Pleione = BU Tauri”, Astronomy and Astrophysics, vol. 516, Art. no. A80, 2010. https://doi.org/10.1051/0004-6361/200913885

[28] K. C. Marr, C. E. Jones, C. Tycner, A. C. Carciofi, and A. C. Fonseca Silva, "The Role of Disk Tearing and Precession in the Observed Variability of Pleione," The Astrophysical Journal, vol. 929, no. 2, p. 150, Apr. 2022, https://ui.adsabs.harvard.edu/link_gateway/2022ApJ...928..145M/doi:10.3847/1538-4357/ac551b

[28] Lutz, T. E. and Kelker, D. H., “On the Use of Trigonometric Parallaxes for the Calibration of Luminosity Systems: Theory”, Publications of the Astronomical Society of the Pacific, vol. 85, no. 507, IOP, p. 573, 1973. https://iopscience.iop.org/article/10.1086/129506#artAbst

[29] Wilson, R. E., “General catalogue of stellar radial velocities.”, Carnegie Institute Washington D.C. Publication, p. 0, 1953. https://ui.adsabs.harvard.edu/abs/1953GCRV..C.....0W/abstract

[30] Torres, G., Latham, D. W., and Quinn, S. N., “Long-term Spectroscopic Survey of the Pleiades Cluster: The Binary Population”, The Astrophysical Journal, vol. 921, no. 2, Art. no. 117, IOP, 2021. https://ui.adsabs.harvard.edu/link_gateway/2021ApJ...921..117T/doi:10.3847/1538-4357/ac1585

Can Posterior AFOs Be 3D Printed Using Reinforced Composites with Optimized Mechanical Performance and Lower Cost Compared to Traditional AFOs?

Meklit Yante, *Howard Community College*
William Diguiseppe, *Howard Community College*
Grace Allen, *Howard Community College*
Mentored by: Mark Edelen, M.S.

Abstract

This research focused on creating a posterior ankle foot orthotic (AFO), addressing two main issues: the expense of functional AFOs often not covered by insurance and the ineffectiveness of cheaper online alternatives. AFOs provide lower extremity support, and this study utilized 3D printing with continuous carbon fiber reinforcement to develop a cost-effective, mechanically equivalent AFO compared to high-cost commercial options. A carbon-fiber reinforced nylon AFO was designed, 3D printed and tested using a custom apparatus to compare flexion stiffness against a purchased carbon fiber AFO and a purchased polyethylene AFO. Results showed that plantarflexion stiffness for the 3D-printed AFO (0.799 Nm/degree) was higher than the carbon fiber AFO (0.643 Nm/degree) and much higher than the polyethylene AFO (0.285 Nm/degree). For dorsiflexion stiffness, the 3D-printed AFO measured 0.204 Nm/degree, the carbon fiber AFO was 0.628 Nm/degree, and the polyethylene AFO was 0.143 Nm/degree. Cost analysis revealed that the 3D-printed AFO was substantially cheaper at $30.79, compared to $509.99 for the carbon fiber AFO and $44.50 for the polyethylene AFO. Weight analysis showed the 3D-printed AFO weighed 1.05 N, while the carbon fiber AFO and polyethylene AFO weighed 1.89 N and 0.891 N respectively. Therefore, the research demonstrates that a 3D printed AFO made using continuous carbon fiber reinforcement has stiffness comparable to traditional carbon fiber AFOs at much lower cost, providing a viable solution for patients.

Introduction

Ankle-foot orthoses are used by people with physical impairments and foot deformities such as foot drop, a condition characterized by the inability to properly lift the front end of the foot [1]. AFOs are often prescribed for individuals with nerve damage, muscle weakness, or alignment issues affecting the lower limb. They help support ankle alignment, improve walking mechanics, and prevent falls by maintaining proper foot positioning during gait [2]. Foot orthoses come in different variations ranging from standard ready-made to custom-fitted braces. Many users of AFOs experience issues such as improper fit and discomfort. With the natural need of the foot to adapt to any uneven terrain, it can become difficult to create a proper design that can mimic the foot's absorption of shock and support of the entire body's weight. Recent investigations into carbon fiber-reinforced nylon filaments have demonstrated that additive manufacturing can produce high-performance components with enhanced mechanical properties and design flexibility [3]. As a result, orthoses have evolved to incorporate more advanced geometries and material combinations, improving patient-specific functionality while lowering production time and cost. In clinical practices, many AFOs use materials such as thermoplastics, UD-flex, and carbon fiber, which tend to be less expensive compared to newer types of AFOs such as AF Servo and TurboMed [4]. In this experiment, an AFO was 3D printed and compared to two purchased AFOs. Using a Markforged X7 industrial printer gave researchers an advantage of creating more optimized designs with newer technologies involved in 3D printing AFOs. The X7 utilizes continuous carbon fiber reinforcement to print parts that have high stiffness-to-weight ratio and sufficient dimensional precision for orthotics [5]. For this research, the AFO was printed using Onyx, a Markforged filament consisting of nylon embedded with chopped carbon fiber; this served as the matrix material through which continuous carbon fiber is deposited in a certain number of layers.

In the human leg, there are two types of movements that take place when a person is walking, dorsiflexion and plantarflexion. Dorsiflexion represents the motion where the forefront of the foot moves upward, and plantarflexion represents the downward motion of the forefront of the foot [6]. For this project, the plantarflexion stiffness, the dorsiflexion stiffness, the cost and the weight of the two commercial off-the-shelf AFOs, one made from carbon fiber and the other from polyethylene, were compared to that of the 3D printed AFO. In order to carry out the experiment, a physical test was conducted in two directions to find the stiffness of each AFO. Previous research experiments conducted to test the strength of 3D printed prosthetic sockets and 3D printed prosthetic feet were reviewed and used as inspiration to design the test rig displayed [7]. Ideas such as position of the material to be tested, the direction to test the plantar stiffness and dorsal stiffness as well as the orientation through which force should be applied were used to set up the experimental design for this research. Based on those inspirations, a custom designed apparatus was prepared and the 3D printed leg wearing the AFO was loaded. The test was done in both a dorsiflexion position and plantarflexion position in separate experiments [8]. Additional information was gathered from research done on the evaluation of experimental setup that was used to test the stiffness of AFOs [9]. This article provided a good starting point in constructing a semi-automated experimental setup [10]. Once the test rig was put in place, the artificial leg wearing the AFO was loaded, then the PASCO Material Testing Machine sensed and recorded simultaneously by using a computer software and semi-automated testing aid. As Hochmann (2020) discusses, although mechanical testing provides important insights, it cannot fully

replicate the long-term performance of AFOs under real-world usage conditions [11]. Although not a focus of this study, this would be an important and interesting area for future research. In addition to that, future studies will be needed to get a better understanding of how these tests can relate to an AFO's full capabilities. This will include the common uses of an AFO and how they can be applied to helping people with physical disabilities, which include treating a variety of musculoskeletal and neurological disorders. This AFO is designed to naturally mimic the foot and leg's movement, helping to maintain proper alignment and providing user with comfort and support while walking. This study aims to use continuous carbon fiber reinforcement to 3D print a posterior AFO with comparable stiffness and lower cost compared to that of a traditional AFO.

Methodology

2.1 Purchasing & Manufacturing of 3D printed AFOs

Three different AFOs were compared based on their strength, stiffness, weight, and cost. Two were purchased and the third one was 3D printed using a Markforged X7 3D printer, which allowed the use of continuous carbon fiber reinforcement to print parts with dimensional accuracy and a high stiffness-to-weight ratio. The goal was to make an AFO that is comparable with the expensive, stiff purchased AFO, but for the cost of the cheaper, low-stiffness AFO. The first brace was manufactured by a company called AliMed, the model was 63497 Swedish AFO. It was made from polyethylene material, and it was purchased for $44.50, see figure 1 on the left. The second brace was manufactured by a company called Brace Direct; the model was Elite Spiral AFO L1951. It was made from carbon fiber and cost $509.99, see (Figure 1) on the right. The third brace was designed using CAD software which went under seven different versions, before reaching a final optimized version, see (Figure 2) for the CAD model AFO and figure 4 for the printed AFO. The production cost was $30.79, and the material used was Onyx, a combination of nylon and carbon fiber. All three AFOs were right leg and sized to fit women's US size 6.

Figure 1: *Purchased Braces; Polyethylene Brace (Left) and Carbon fiber Brace (Right)*

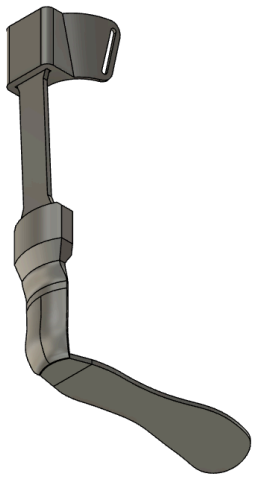


Figure 2: *CAD model of the 3D printed AFO*

With this design, the AFO was then 3D printed under the Markforged X7 which took 21 and a half hours. The design needed to be printed with separate parts due to several reasons. The main reason being that printing the separate parts allows the optimization of stiffness in specific directions and prevents the weak z-axis. In addition to that, printing the parts separately reduces the cost by minimizing the amount of support material, which allows for customization of stiffness by altering the number of layers incorporated, where increased number of layers yield higher stiffness and vice versa. Lastly, it makes it easier to repair because just the broken part can be replaced instead of the whole AFO. Therefore, the three parts were printed separately and were assembled to yield the AFO displayed in (Figure 4).

Figure 3: *Markforged X7 3D printer used to print the AFO and the artificial leg*

Figure 4: *Photograph of 3D printed AFO, composed of three parts; the leg attachment, the adjustable rod, and the foot support.*

2.2 Continuous carbon fiber reinforced AFO design

Carbon fiber reinforcement filaments were layered throughout the middle of the AFO with 32 layers. This layout is demonstrated in (Figure 5) where the blue lines represent the layout of the continuous carbon fiber reinforcement. The MarkForged X7 can print with multiple materials. Nylon reinforced with carbon fiber was the material used for this brace. To accurately assess its stiffness and performance under applied force, a detailed model was created to examine these factors and other functional characteristics.

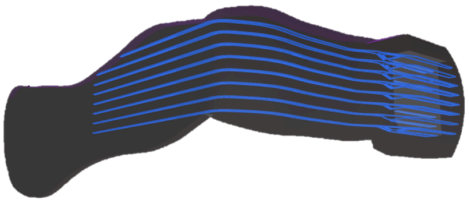


Figure 5: *CAD model of the interior of the printed AFO displaying the layers of the carbon fiber*

2.3 Experimental setup of the artificial leg wearing the AFO loaded into the testing apparatus

In order to obtain numerical data for the experiment, the setup shown on figure 6 was created and the testing apparatus shown on figure 7 and was used to collect data. The PASCO ME-8236 material testing apparatus was used as part of the test rig. Using computer software connected to the physical machine, data was collected simultaneously while running the experiment. The PASCO apparatus applied force using a push pin force mechanism while winding it down manually with a crank. When the roller bearing touched the surface, a graph was generated on a computer screen through a software called Capstone as displayed on figure 8. This recorded the force applied to the brace, as well as the displacement of that brace as the result of the applied force.

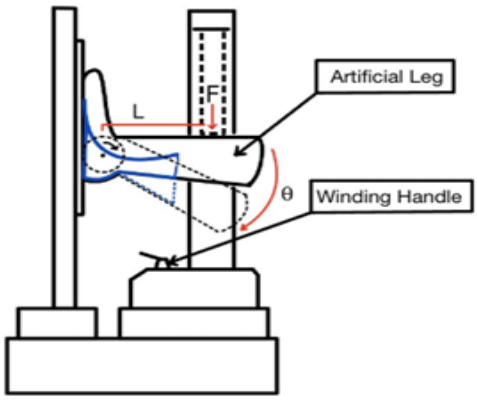


Figure 6: *Diagram of test apparatus, showing the movement path (dotted lines) as F force is applied. The angle created (**θ**) and the distance (L) from the pivot point to the force application are labeled. Red markings indicate key variables, while blue markings show the brace's location.*

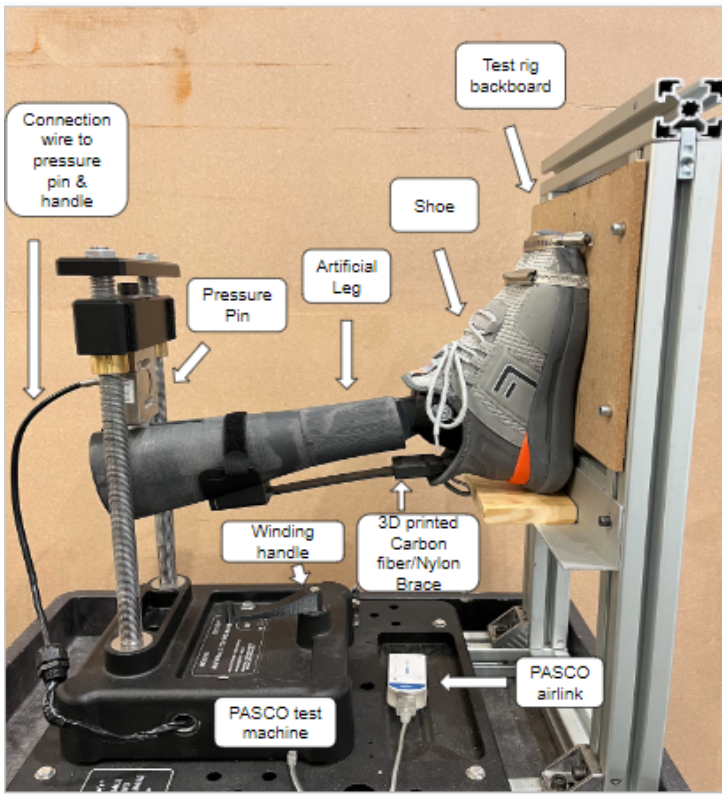


Figure 7: *Testing Apparatus*

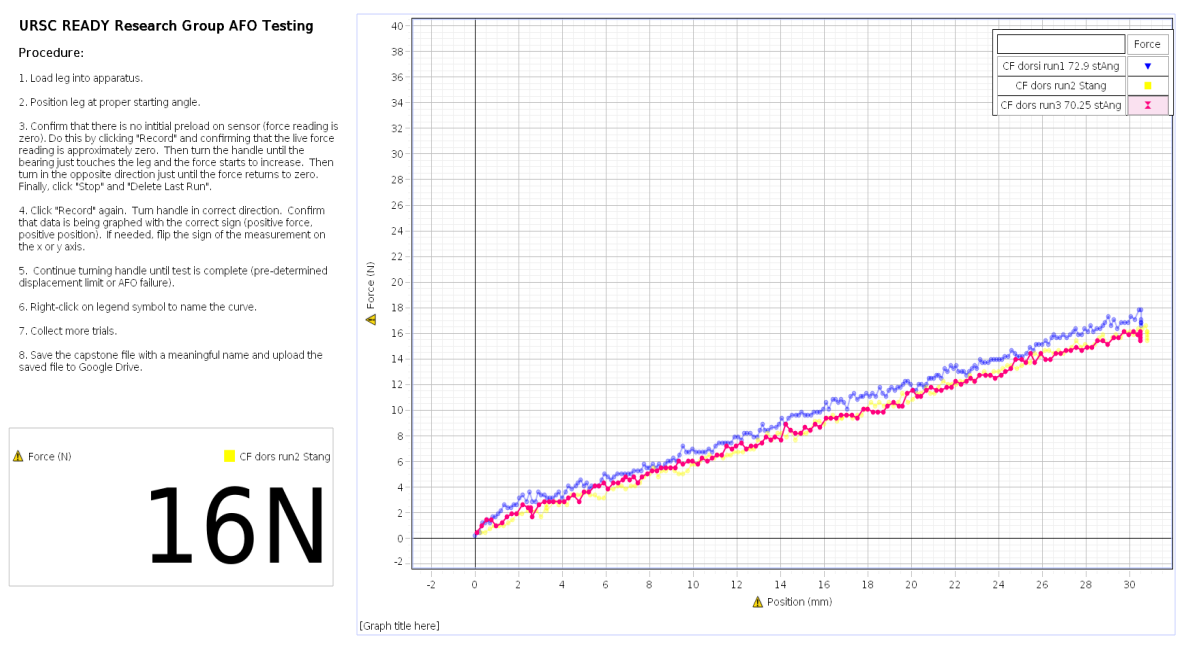


Figure 8: *Example raw data (force vs position) collected through Capstone*

The test rig design involved a modified apparatus that kept the artificial leg in place. A shoe was purchased and placed on the foot of the artificial leg to give a more realistic test and to support by using the friction of the bottom of the shoe to secure it in place. The design of the apparatus supported both plantarflexion and dorsiflexion position. As the person conducting the experiment applied force downward using the manual hand crank, the testing apparatus began to lower down to the inside crevice of the leg. The angle of the leg was taken at the beginning of each test for the conversion to torque vs. angle to obtain proper stiffness analysis. Once the roller bearing touched the leg, the force and displacement mentioned above were collected. After that, the raw data for force was converted to torque using the formula displayed next to equation 1 and the displacement was converted to angle using the formula displayed next to equation 2.

Equation 1 $\tau = FL$

where F is the vertical force applied to the leg and L is the length of the leg.

Equation 2 $\Theta = \tan^{-1}(\delta/L)$

where δ is the vertical displacement of the pin applying force to the leg.

2.4 Manufacturing and analysis of 3D printed model leg

A leg design was made to mimic the structure of a young adult female. This gave the braces something to attach to and simulated how the leg would move, and resist force exerted by the weight of the person wearing it. Using the MarkForged X7 3D printer, the artificial leg

displayed on figure 9 was printed. This artificial leg resembled the anatomy of that of a typical human leg, thus it was compatible with the three AFOs tested.

Figure 9: *3D printed artificial leg used for testing*

Results

The study conducted tests to evaluate the mechanical properties and cost-effectiveness of the 3D printed AFO compared to traditional options. Through rigorous experimentation and analysis, it was found that the 3D printed AFO made from nylon with continuous carbon fiber reinforcement exhibited impressive plantarflexion stiffness, measuring at 0.7985 Nm/degree. This result was particularly significant as it closely matched the stiffness of the purchased carbon fiber AFO which was 0.6429 Nm/degree- renowned for its high stiffness and effectiveness in providing support for patients with foot drop. Conversely, the purchased polyethylene AFO, while more affordable, demonstrated significantly lower plantarflexion stiffness value of 0.2847 Nm/degree, indicating potential limitations in providing adequate support for individuals with foot drop. Compared to plantarflexion, the dorsiflexion stiffness recorded was lower, measured at 0.2039 Nm/degree for the 3D printed AFO made from nylon with continuous carbon fiber reinforcement, 0.6429 Nm/degree for the purchased carbon fiber AFO and 0.2847 Nm/degree for the polyethylene AFO. Since foot drop primarily affects the ability to lift the foot during the swing phase, some reduction in dorsiflexion stiffness may actually support smoother toe clearance and a more natural gait. As long as plantarflexion is adequately controlled for stability, lower dorsiflexion stiffness may not significantly hinder overall AFO performance, offering flexibility in design without compromising functional support. However, further research will be required to better support this observation and fully understand its clinical implications. In addition to mechanical performance, the study also examined the cost-effectiveness of the different AFO options. The 3D printed AFO emerged as a highly cost-effective solution, with a production cost of only $30.79. This cost was much lower than the purchased carbon fiber AFO, priced at $509.99 while remaining competitive with the polyethylene AFO, which cost $44.50. The results showed that the printed carbon fiber AFO weighed 1.05 N, while the purchased carbon fiber AFO weighed 1.89 N, and the purchased polyethylene AFO weighed 0.891 N. Overall, the findings of this experiment are substantial, as they demonstrate the potential for

advanced manufacturing techniques like 3D printing to significantly reduce the financial burden associated with acquiring essential medical devices such as AFOs.

	Purchased Carbon Fiber	Purchased Polyethylene	Printed CF-Nylon
Dorsal Stiffness (Nm/degree)	0.6279	0.1425	0.2039
Plantar Stiffness (Nm/degree)	0.6429	0.2847	0.7985
Weight (N)	1.89	0.891	1.05
Cost (USD)	$509.99	$44.50	$30.79

Table 1: *Summary data table for all three braces that were tested. The cost for each brace reflects the purchase value for the first two AFOs and the material costs for the third AFO*

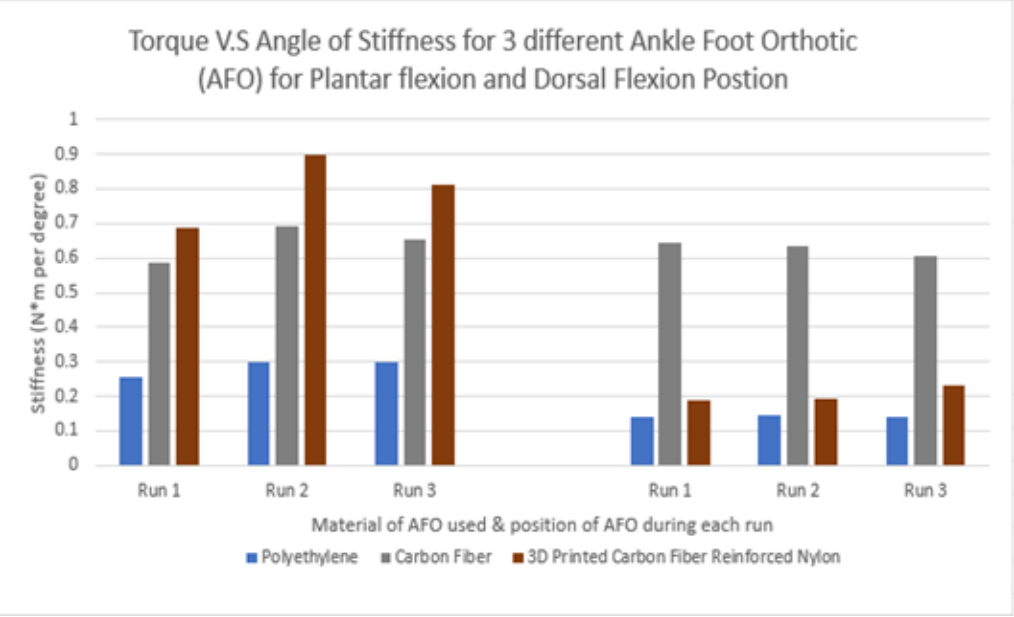


Figure 10: *Stiffness comparison, including all trials*

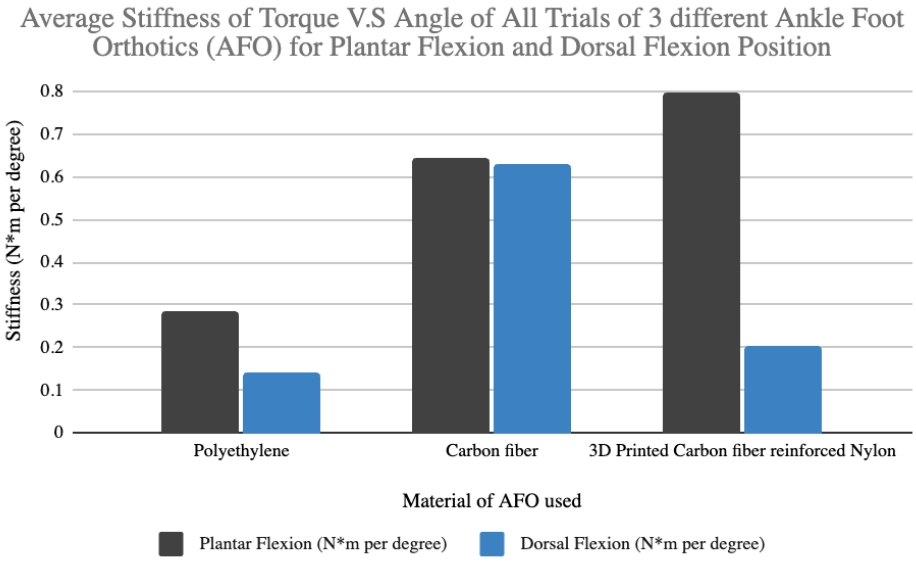


Figure 11: *Average stiffness comparison*

Discussion

The stiffness of an AFO is of paramount importance in effectively managing foot drop and providing stability during walking. Proper stiffness ensures that the AFO can resist deformations under load and maintain the desired foot alignment throughout the gait cycle. For patients with foot drop, achieving the optimal balance of stiffness is crucial, as excessively stiff AFOs may restrict natural foot movement and lead to discomfort or skin irritation, while inadequately stiff AFOs may fail to provide sufficient support, compromising mobility and safety; the data from this study highlights the functional significance of stiffness in AFOs. Although there is not a universal optimal stiffness range for all AFO users, factors such as patient's gender, anatomy of their leg, weight, activity level, and gait abnormalities must be considered in determining the appropriate stiffness level for each individual and the unique design of the 3D printed AFO makes it possible to tailor the brace to achieve different stiffnesses by changing the number of carbon fiber layers. When compared to the traditional carbon fiber AFO, the stiffness proved to be higher in the planar flexion stiffness and lower in the dorsal flexion stiffness. Considering that the 3D printed AFO is made for patients with foot drop whose plantarflexion is very strong and their dorsal flexion is weak, they require a brace with strong planar stiffness that supports the pressure applied by their foot and light dorsal stiffness to maintain balance between the upward and downward position of the foot. Therefore, the 3D printed AFO with continuous carbon fiber reinforcement demonstrated its potential to provide effective support for patients with footdrop while offering a more affordable alternative.

Conclusion

In conclusion, the findings of this research support the feasibility and effectiveness of utilizing 3D printing and continuous carbon fiber reinforcement to produce cost-effective AFOs with comparable stiffness to traditional options. By addressing both the mechanical and financial aspects of AFO design, this approach has the potential to significantly improve access to

essential assistive devices for patients with footdrop, ultimately enhancing their mobility and quality of life. However, it's important to acknowledge the limitations of the study and identify areas for future research. Specifically, additional investigations are needed to explore factors such as comfort, which was not addressed in this study since this experiment was conducted on a 3D printed foot. Understanding these factors would provide a more comprehensive assessment of AFO capabilities and limitations, ensuring optimal design and functionality for individual patient needs. Additionally, future studies could explore how the number of layers in 3D printed AFOs can be modified to achieve a desired stiffness. Another future study that could be of interest involves integrating smart technology into the 3D printed AFOs to send walking reminders to the user, track steps, and report to healthcare providers. This advancement could be valuable in helping patients reduce their long-term dependence on AFOs as it could encourage consistent movement and support recovery. While it may not benefit individuals with complete nerve damage, it holds significant potential for those with muscle weakness or alignment issues. Over time, the stiffness can be gradually decreased as the patient gains strength and/or stability, potentially reaching a point where minimal support or no AFO at all is required. While the integration of technology may result in a slight increase in the cost of the AFOs, the added functionality would offer significant value to the user.

Acknowledgements

We would like to express our sincere gratitude to the Engineering Lab at Howard Community College (HCC) for providing the resources essential to our research. We are especially thankful to the faculty of the Undergraduate Research and Science Curriculum (URSC) program for their continued guidance and support. The well-structured, two-year curriculum has been instrumental in shaping our research journey. We also gratefully acknowledge the program's generous funding, which made this project possible.

Contact: medelen@gmail.com**,** meklityante@gmail.com**,** willdiguiseppe1@yahoo.com, gracenallen@gmail.com

---

References

[1] E. Wojciechowski *et al*., "*Feasibility of designing, manufacturing and delivering 3D printed ankle-foot orthoses: A systematic review*," *Journal of Foot and Ankle Research*, vol. 12, no. 1, Jan. 2019, doi: 10.1186/s13047-019-0321-6.

[2] C. Hunter, "Foot orthotics assessment," *Physiopedia*, [Online]. Available: https://www.physio-pedia.com/Foot_Orthotics_Assessment. [Accessed: 20-Mar-2023].

[3] F. Calignano, F. Lavecchia, G. Maizza, and M. Manfredi, "*Investigation of the mechanical properties of a carbon fibre-reinforced nylon filament for 3D printing,*" *Machines*, vol. 8, no. 4, pp. 74:6-9, Dec. 2020, doi: 10.3390/machines8040074.

[4] S. Y. Lee, J. S. Jung, and H. J. Shin, "*Commonly used types and recent development of ankle-foot orthosis: A narrative review,*" *Healthcare*, vol. 9, no. 6, Art. no. 696, pp. 8, Jun. 2021, doi: 10.3390/healthcare9060696.

[5] C. Ma and J. M. T. Thompson, "*Drivers of mechanical performance variance in 3D-printed fused filament fabrication parts: An Onyx FR case study*," *Polymer Composites*, vol. 42, no. 10, pp. 5045–5057, Oct. 2021, doi: 10.1002/pc.26145.

[6] Lumen Learning, "Types of body movements," *Lumen Learning*, [Online]. Available: https://courses.lumenlearning.com/suny-ap1/chapter/types-of-body-movements/. [Accessed: 27-Dec- 2022].

[7] S. Kim, J. K. Lee, and H. Park, "*3D printed transtibial prosthetic sockets: A systematic review,*" *Materials*, vol. 15, no. 4, Art. no. 1532, pp. 7–8, Feb. 2022, doi: 10.3390/ma15041532.

[8] M. Stelt and R. Wilke, "*Strength testing of low-cost 3D printed transtibial prosthetic socket,*" Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, vol. 235, no. 10, Oct. 2021, doi: 10.1177/09544119211031211.

[9] H. Warder, "*Examining the viability of carbon fiber reinforced three-dimensionally printed prosthetic feet created by composite filament fabrication,*" *International Society for Prosthetics and Orthotics*, Conf. Proc., 2018.

[10] A. Lelapi, G. Di Perri, D. Di Giuseppe, and G. Cappa, "*A novel experimental setup for evaluating the stiffness of ankle-foot orthoses*," *BMC Research Notes*, vol. 11, Art. no. 792, 2018, doi: 10.1186/s13104-018-3904-7.

[11] A. Hochmann, "Testing procedures for ankle foot orthoses," *Orthopädie Technik*, vol. 6, 2020.

"Butterflies"

Shannon Davis
Mixed media collage

I was drawn to this topic because it combines the beauty of the black aesthetic with past and future technologies. I believe it's an innovative way to explore and learn more about how the Afro community and culture evolves even under harsh realities. I think this piece demonstrates how powerful the resilience and influence the black community holds in a unique society.

My creative process was to use a mixed media approach combining watercolor, magazines, metal and natural elements which again reinforces and complements the overall theme. Collectively using different elements to achieve a full spectrum of textures, colors and shapes to interpret the Afrofuturism experience.

The overall concept was to place the focus on a Afro woman in her natural state with old and new technologies within herself and outside of her embodying her true essence and connection of duality into one energy which is her.

The Impact of Digital Storytelling: Unveiling Untold Stories within a Diverse Community College Student Population

Satya Kari, *Howard Community College*
Layla Hamam, *Howard Community College*
Christian Nazaire, *Howard Community College*
Nikki Kreizel, *Howard Community College*
Dojin Lee, *Howard Community College*
Liza Pon, *Howard Community College*
Stephanie Simpson, *Howard Community College*
Isaac Schofer, *Howard Community College*
Mentored by: Cheryl Campo, Ph.D., J.D., and Bethany Pautrat, M.A.

Abstract

Issues related to the untold stories of individuals' experiences belonging to specific affinity groups can be prevalent in society and college communities. Our team chose to examine how digital storytelling can amplify the untold experiences of community college students from diverse affinity groups, aiming to bring awareness and representation to their often overlooked narratives. An in-depth literature review of peer-reviewed sources from the Howard Community College (HCC) library database revealed that many students experience discrimination based on factors tied to their respective affinity groups [1]. Sharing personal stories can illuminate these students' experiences, challenge prevailing narratives, and represent various perspectives [2]. One effective method for sharing these stories is through documentary films, which can authentically capture individuals' lived experiences, resulting in genuine and enlightening insights [3]. From the review findings, the team found an unmet need in the community to gather and share the often untold stories of community college students and advisors belonging to unique groups on our college's campus. The effectiveness of digital storytelling was investigated through a combination of interviews, qualitative data collection, and a screening event to capture and share overlooked stories within HCC and the local community. The project's impact was to raise awareness about the experiences of untold stories, strengthen connections across diverse groups within HCC and the local community, and provide a platform for individuals to share their lived experiences. Results from the surveys collected after the screening were positive. Participants reported a better

understanding of the various affinity groups on campus and believed digital storytelling to be an effective medium in representing these groups and their real-life experiences.

Introduction

The Honors-in-Action Project (HIA), undertaken by the Alpha Alpha Sigma Chapter of Phi Theta Kappa (PTK), sought to understand how digital storytelling can be used to amplify the voices of underrepresented student communities from various cohorts at a community college. The HIA project combines academic research into the PTK Honors Study Topic and community action to solve real-world challenges. Each year, PTK chapters are given a specific Study Topic that serves as the focus of the chapter's HIA. Each new topic is developed by the Honors Program Council, Phi Theta Kappa's very own "think tank", which is composed of chapter advisors, consultants, and PTK staff. This year's study topic was, *"The Power of Stories,"* which inspired our chapter to focus on the concept of untold stories—particularly those of underrepresented student groups whose lived experiences are often overlooked [4].

From this central idea of untold stories, our original research question emerged: *How effective is digital storytelling in capturing and sharing these often unheard narratives within the local community?* In other words, we sought to understand how digital storytelling could shed light on the lived experiences of students who may not typically have their stories heard, and whether shared storytelling could reveal common challenges across different student groups.

Digital storytelling refers to the use of computer-based tools to combine multimedia—such as graphics, audio, and video—with the art of personal storytelling [5]. For our project, we focused on three affinity groups at HCC: Howard PRIDE, which supports the academic and professional growth of minority male students; Parent Scholars, which assists low-income and/or student-parents in accessing resources to succeed; and Friends Across Borders, a mentorship program that pairs F1 visa students with current students to support cultural and academic adjustment [6, 7]. This method of media was chosen to make the student's stories more personal and accessible.

Our literature review revealed that community college students often face discrimination based on factors tied to their affinity groups [1]. A qualitative study by Samanta highlighted the untold experiences of Asian and Asian American women in community colleges, reinforcing the lack of representation in traditional narratives [8]. Additional studies emphasized the power of storytelling methodologies in capturing personal experiences: Souza and Gupta argue that interviews are a vital medium for enabling marginalized voices to be heard, while Fitzgerald and Lowe assert that documentary filmmaking serves not only as an expressive tool but also as a valid research process [2, 3]. These findings affirmed the value of capturing lived experience authentically and informed our decision to use documentary film and qualitative interviews to amplify student voices at HCC.

The goal of our project was to investigate whether creating a platform for sharing untold stories could raise awareness and demonstrate the importance of representation. Our primary research questions focused on: 1) viewers' feedback and reactions after viewing the untold

stories from different affinity groups; 2) whether digital storytelling would bring awareness and representation to the experiences of students and faculty at community colleges; and 3) if digital storytelling is an effective way to unveil the untold stories and experiences of students and faculty associated with various affinity groups on our campus to the local community.

Based on our initial literature review, we developed the hypothesis that *digital storytelling is an effective approach for increasing comfort, fostering open discussions about concerns, and unveiling the untold stories of diverse student affinity groups at HCC*. This hypothesis aligns closely with our chosen theme of "Representation Through Stories".

Methods and Materials

This research involved collaboration and multiple steps of implementation. We began by collaborating with Dr. Trent Haines, a psychology professor at Morgan State University, who provided videography resources and expertise. To identify participants for interviews, we held meetings with affinity group advisors on campus to select students willing to share their stories. Once the participants were selected, interviews took place in the HCC Honors Commons. This location was selected with the intent to conduct interviews in a comfortable academic setting that presented the least amount of obstacles for filming (lighting, acoustics, etc.).

PTK volunteers and Dr. Haines assisted in setting up the studio. After filming, we collaborated with Sasha DeBenedictis, an Honors student at HCC, to edit the footage into a 25-minute film. To evaluate the effectiveness of digital storytelling, we held two screenings advertised to all HCC students, inviting their families and friends through Canvas announcements, fliers passed around to students, and word-of-mouth. During the screenings, printed pre- and post-surveys were handed out to all viewers. These surveys were designed to gather feedback and reactions to determine whether digital storytelling effectively raises awareness and conveys important narratives to the viewers. After the screening, survey data was analyzed in Google Sheets with additional per-question t-tests performed in R 4.5.0.

Results

Central Themes of Interviews

Across interviews, students described feeling undervalued or misunderstood in their daily interactions with others. For instance, international students noted that others often assumed they could not speak English, while student-parents expressed concern that faculty might view them as taking advantage of available resources. Student-parents also reflected on being perceived as having easier lives than was actually the case, despite managing significant responsibilities outside school. International students also noted challenges in transitioning to a U.S. community college environment, including student status restrictions, visa-related job limitations, and lengthy commutes that contributed to academic and personal stress.

Despite personal challenges, students emphasized the value of community. Both students and advisors from Parent Scholars, Friends Across Borders, and Howard PRIDE described these programs as spaces where students felt seen, supported, and encouraged. They highlighted the

role of an inclusive educational environment in helping students stay motivated and achieve their goals. One student described the strong sense of "brotherhood" that emerged within their cohort, underscoring the deep emotional support these programs provide. Friends Across Borders, a program serving international students, fosters connection through a peer mentoring system that pairs newer students with those more experienced in navigating the academic and cultural transition of entering an American college.

Students frequently described experiencing a heightened pressure to succeed academically, personally, and socially. For student-parents, this included balancing academic responsibilities with caregiving, while feeling a strong commitment to support their children's future. A student affiliated with PRIDE reflected on the emotional weight of questioning whether they were doing "enough," even while actively involved in campus life. This ongoing sense of striving was often linked to a strong sense of responsibility and a desire to meet both internal and external expectations.

Figure 1: *Affinity group participants and advisors featured in interview segments of the documentary*

Across all interviews, students consistently expressed positivity in the face of difficulty, which included systemic barriers, time constraints, and cultural transitions. Many expressed gratitude for the resources and relationships they had access to and saw their educational journey as an opportunity for personal growth. Their ability to remain optimistic and forward-focused, even under difficult circumstances, was a defining feature of their narratives and a powerful reflection of their perseverance.

Survey Findings

Among the eighteen participants who attended the screening and completed the pre- and post-surveys, all reported an increased understanding of the various affinity groups represented on campus. Each participant also expressed that digital storytelling was a powerful and meaningful method for capturing and conveying the real-life experiences of students and advisors from a range of backgrounds.

From pre- to post-survey, average scores for Questions 1–3, which focused on knowledge of the HCC affinity groups (Howard PRIDE, Parent Scholars, and Friends Across Borders), increased more sharply than those for Questions 4–7, which focused on participants' impressions of digital storytelling as a medium. These trends suggest that the documentary had a stronger influence on increasing awareness of student groups than it did on shifting perceptions of digital storytelling itself.

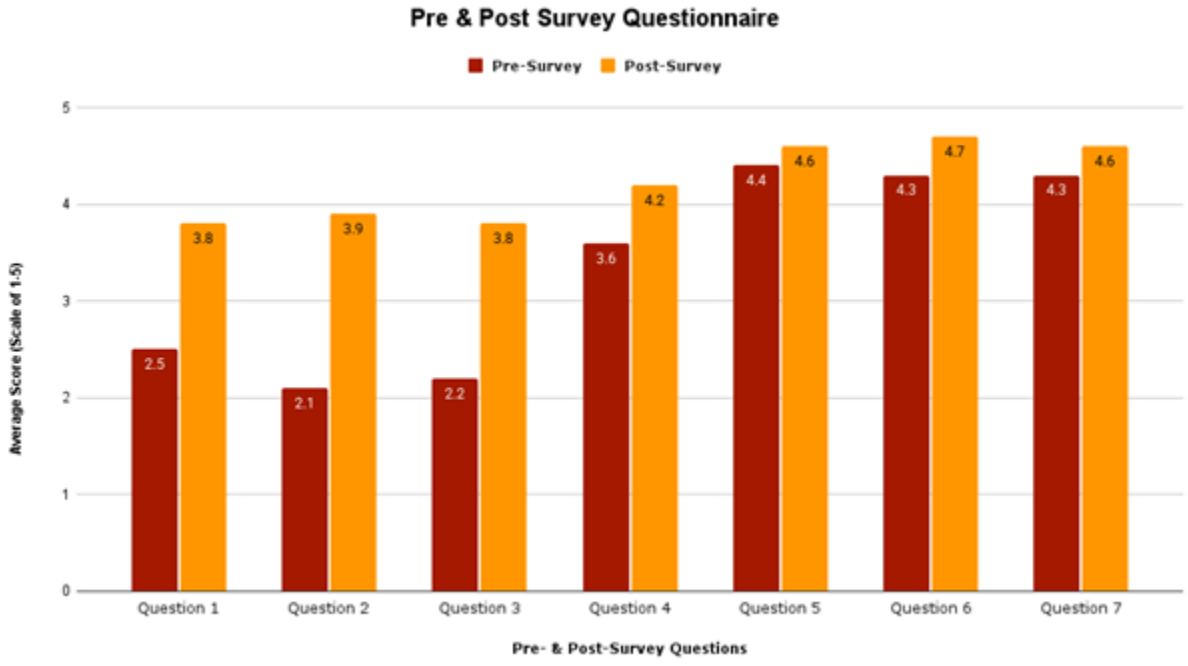


Figure 2: *Pre- and Post-Survey Questionnaire Data*

Question 1	How much do you now know about "Howard PRIDE" as an affinity group on campus?
Question 2	How much do you now know about "Parent Scholars" as an affinity group on campus?
Question 3	How much do you now know about "International Students" as an affinity group on campus?
Question 4	How interested are you in learning about the experiences of these affinity groups?
Question 5	How effective do you believe digital storytelling (e.g., documentaries) is in conveying important narratives?
Question 6	How effective do you think storytelling is in raising awareness of the untold stories of special affinity groups?
Question 7	How often do you think stories of special affinity groups on college campuses go untold?

Table 1: *Pre- and Post-Survey Questions*

Welch's two-sample t-tests were performed on each pair of pre- and post-survey questions to evaluate changes in participants' responses following the screening. Each t-test checked whether respondents' scores improved (H_1: $\mu 2 - \mu 1 > 0$), where μ is the average score for each respective question. All tests were conducted using an 80% confidence interval. Although average scores increased across all seven questions, none of the comparisons reached statistical significance. The p-values for each test were at or above 0.4185.

	t-value	Lower confidence interval	p-value
Question 1	0	-1.690405	0.5
Question 2	0	-2.160469	0.5
Question 3	0	-1.967867	0.5
Question 4	0	-0.9450163	0.5
Question 5	0	-0.3637845	0.5
Question 6	0	-0.6637718	0.5
Question 7	0.20772	-0.5618188	0.4185

Table 2: *80% t-tests on results of each question* $H_1 > \mu_2 - \mu_1$

Viewer comments further supported the survey findings:

> “It’s extremely powerful. It makes a difference in understanding."
> “I think personal stories are emotional, motivational, and effective in sharing awareness of obstacles, barriers, and wants to encourage and increase success."
> "It's a way to highlight individuals that might not get their story heard."
> “Everyday people have stories to tell.”
> “I am more conscious about what other people go through and not to judge on face value.”
> “I love them :) I think it makes you think more about the world around you, because people tend to get stuck in their own bubble.”

Discussion

Data Analysis

The data collected from our Honors in Action project revealed encouraging outcomes for the future use of digital storytelling in educational and community settings. Interviewees showed more comfort in opening up about their stories and experiences, possibly because of the intimate atmosphere of being interviewed by fellow students.

The most substantial increases occurred in Questions 1–3, which measured viewers’ knowledge of the three HCC cohorts. This suggests that the documentary was more effective at improving viewers’ understanding of the affinity groups themselves than it was at influencing their perceptions of digital storytelling as a method of increasing empathy and awareness (Questions 4–7). This may, in part, be due to participants already valuing storytelling prior to the screening or being less familiar with the specific student groups featured in the documentary.

Despite the change in averages, the t-tests could not conclusively verify the score increase. This outcome was not unexpected given the small sample size and use of convenience sampling. With only eighteen participants, the study may not have had enough statistical evidence to detect meaningful differences. However, the increase in average scores across all survey questions, paired with the overwhelmingly positive comments, suggests a promising trend.

Several factors may have influenced the statistical outcomes. The small sample size limited the strength of the analysis, and the convenience sampling method introduced the potential for bias. Furthermore, only nine individuals were interviewed for the documentary, and due to editing constraints, many hours of footage were not included in the final documentary video.

To strengthen future research, improvements could include increasing the sample size, incorporating random sampling techniques, and hosting additional screenings both on and off campus. These adjustments could allow for broader community engagement and provide a more representative understanding of the stories shared.

Connections to Literature Review

One prominent theme in student and advisor interviews was the feeling of being undervalued or misunderstood. International students shared that others often assumed they could not speak English or lacked academic preparation, while student-parents expressed concern that faculty might view them as taking unfair advantage of resources. The assumptions placed on affinity groups often masked the complex realities students faced, such as caregiving responsibilities, long commutes, or cultural transitions. The theme of being undervalued aligns with prior research on how underrepresented students manage misperceptions while balancing academic and personal demands [1]. Digital storytelling gave participants space to express these nuanced experiences on their own terms, challenging reductive assumptions and affirming their identities.

Another central finding was the importance of community and belonging. Students and advisors across all three affinity groups described their programs as more than academic support systems—they were safe, affirming spaces where individuals could connect with others who understood their experiences. Friends Across Borders facilitated meaningful peer mentorship among international students, Parent Scholars created a support network for caregiving students, and PRIDE fostered what one student described as a "brotherhood." These descriptions reinforce Fitzgerald and Lowe's framing of documentary storytelling as a process that not only documents experience but also strengthens social cohesion and community resilience [3].

Students also discussed an ongoing pressure to succeed academically, personally, and socially. For student-parents, this often meant striving to meet academic goals while also serving as role models and primary caregivers. Others expressed the emotional weight of questioning whether they were doing "enough," even while highly engaged on campus. This pressure was frequently driven by a strong sense of responsibility and a desire to meet expectations, both internal and external. Storytelling in this context allowed students to reflect openly on these feelings and acknowledge their progress without minimizing their challenges.

Despite the obstacles described, nearly every student spoke with a sense of optimism and forward-thinking. Whether navigating immigration systems, financial strain, or time constraints, participants consistently expressed gratitude for the opportunities they had and the communities they belonged to. This aligns with research by Samanta, which suggests that marginalized students often draw strength from adversity and find meaning in educational pursuits as pathways to growth [8].

Taken together, these themes demonstrate how digital storytelling serves as both a reflective process and a meaningful catalyst for student voice. By sharing their lived experiences, students were able to engage more deeply with their identities, express challenges that are often unseen, and connect with others through shared understanding. While the quantitative findings were limited by sample size, the richness of the qualitative insights highlights the potential of digital storytelling to increase awareness, strengthen communication across diverse campus communities, and offer a meaningful way for students to speak to their experiences with honesty and clarity.

Conclusion and Future Work

This project demonstrated that digital storytelling is an impactful and accessible method for unveiling the untold stories of students and faculty from underrepresented affinity groups at HCC. While quantitative data was inconclusive due to sample size and sampling methods, the strong qualitative responses emphasized the emotional and educational value of the film.

By amplifying the voices of students who are often underrepresented, this project contributed to a more inclusive campus culture and provided a platform for meaningful conversations around identity and community. The results support the continued use and expansion of digital storytelling initiatives to foster empathy, promote understanding, and strengthen connections across diverse populations within the college and the broader community.

Future work could involve expanding the number of screenings to reach wider audiences, implementing a longitudinal survey design to capture change over time, and incorporating participant feedback directly into future productions. These enhancements would serve to strengthen both the storytelling process and the depth of its impact within and beyond the academic environment.

Acknowledgements

We would like to express our deepest gratitude to the Planning, Research and Organizational Development team for their invaluable guidance, patience, and encouragement throughout this research. We are especially thankful to Phi Theta Kappa for awarding us $1,000 through the *Honors in Action grant*, which provided vital financial support for the development and execution of this project. We also extend our sincere thanks to our advisors, Dr. Cheryl Campo and Ms. Bethany Pautrat; to Dr. Trent Haines, whose expertise and time were instrumental in guiding the film production; and to Sasha DeBenedictis for his thoughtful and timely editing. Lastly, we thank the entire Alpha Alpha Sigma Chapter leadership team for their dedication and collaborative effort in this research project.

Contact: ptk@howardcc.edu, lhamam@howardcc.edu, cnazaire@howardcc.edu, nikki.kreizel@howardcc.edu, satya.kari@howardcc.edu, liza.pon@howardcc.edu, dojin.lee@howardcc.edu, stephanie.simpson@howardcc.edu, isaac.schofer@howardcc.edu, bpautrat@howardcc.edu, ccampo@howardcc.edu

---

References

[1] C. Mahoney, B. J. Becerra, D. Arias, J. E. Romano, and M. B. Becerra, "'We've Always Been Kind of Kicked to the Curb': A Mixed-Methods Assessment of Discrimination Experiences among College Students," International Journal of Environmental Research and Public Health, vol. 19, no. 15, p. 9607, Aug. 2022, doi: https://doi.org/10.3390/ijerph19159607.

[2] S. P. de Souza and S. Gupta, “14. Why Stories Matter for Representation, Action, and Collectivization,” *Feminist Futures of Work*, pp. 197–206, Dec. 2023, doi: https://doi.org/10.1515/9789048556892-017.

[3] A. Fitzgerald and M. Lowe, “Acknowledging Documentary Filmmaking as not Only an Output but a Research Process: A Case for Quality Research Practice,” *International Journal of Qualitative Methods*, vol. 19, p. 160940692095746, Jan. 2020, doi: https://doi.org/10.1177/1609406920957462.

[4] “Five Star Chapter Plan,” *Phi Theta Kappa*, Aug. 15, 2024. https://www.ptk.org/five-star-chapter-plan/ (accessed Mar. 25, 2025).

[5] “Educational Uses of Digital Storytelling,” *Uh.edu*, 2019. https://digitalstorytelling.coe.uh.edu/page.cfm?id=27&cid=27

[6] H. C. College, “Parent Scholars Program | Howard Community College,” *Howardcc.edu*, 2024. https://www.howardcc.edu/services--support/academic-support/academic-support-programs/parent-scholars-program/ (accessed Mar. 25, 2025).

[7] H. C. College, “You Are Welcome Here | Howard Community College,” *Howardcc.edu*, 2021. https://www.howardcc.edu/about-us/news--press/news/you-are-welcome-here/ (accessed Mar. 25, 2025).

[8] S. Samanta, “The American Community College as ‘Stepping Stone’: Opportunity, Agency, and Family in Asian and Asian American Women’s Educational Histories,” *Journal of Asian American Studies*, vol. 21, no. 3, pp. 367–393, 2018, doi: https://doi.org/10.1353/jaas.2018.0024.

[9] C. W. Cheah, K. Y. Koay, and K. Xiang, “Uncovering the Voices of Marginalized Minorities in Public Policy Research - A Critical Review of the Image and Text-Based Vignette Method,” *International Journal of Qualitative Methods*, vol. 22, p. 160940692311634, Jan. 2023, doi: https://doi.org/10.1177/16094069231163429.

[10] S. KC, “The untold stories of resilience, reworking and resistance of ageing non-European migrant women,” *European Journal of Social Work*, pp. 1–12, Jul. 2024, doi: https://doi.org/10.1080/13691457.2024.2368255.

[11] S. Robinson, “From the president’s desk: #EndCCStigma: Social media as a tool to change public perception of 2‐year colleges,” *New Directions for Community Colleges*, vol. 2022, no. 197, pp. 141–155, Dec. 2021, doi: https://doi.org/10.1002/cc.20503.

Exploring Global Variations in Suicide Rates: A Sociological Perspective

Greg Smith, *Howard Community College*
Mentored by: Greg Fleisher, M.S.

Abstract

This article investigates the differing suicide rates from contrasting cultures across the world – namely the United States, and South Korea – based on data from multiple demographics of people, and asks: why are there such significant and noticeable differences between these groups? Using a meta-analysis approach, this article uses research findings from across the globe to try and understand where similarities and differences can be found in suicide statistics. Throughout this article, attempts are made to find strong correlations between suicide and sociological factors from various cultures and demographics of people, not to establish a concrete cause for suicide, but to infer that some factors may make certain people more susceptible to suicide than others. Sociological theories are applied to various types of suicide when appropriate. In doing so, the findings and suggestions within this piece may be useful in finding ways to slow or stop the crisis of suicide across the world.

Introduction and Method

Suicide is the act and consequence of intentionally taking one's own life, and it is a devastating issue in many societies today, with an estimated 703,000 deaths by suicide occurring globally each year [1]. While some countries experience relatively low suicide rates, other countries are seeing very high numbers, like the Republic of Korea's 28.6 per 100,000 in 2019 [2]. For reference, according to the World Health Organization, the United States stood at 15.6 deaths by suicide per 100,000 people in 2021 [2]. Figure 1 [3] illustrates some examples of vast international differences in suicide rates.

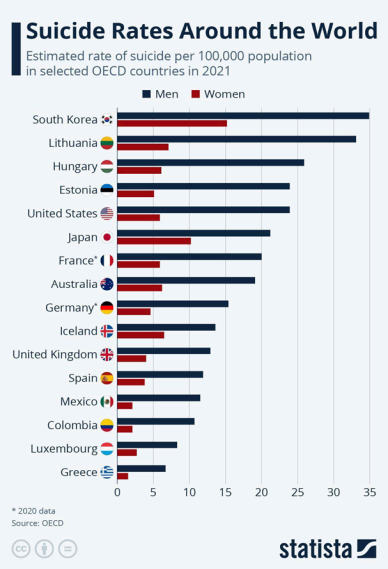


***Figure 1**: Variations in suicide rates in a select group of countries in the year 2021, visualized by country and then split into male/female suicides per 100,000 population.*

This paper investigates the potential sociological explanations for the vast differences between suicide rates in various countries, making comparisons between sociocultural demographics such as gender, socioeconomic status, and race, and raising further questions about what factors might be affecting these differences. To highlight contrasting cultures, the focus of this paper will be the differences between South Korea, and the United States. However, it should be noted that researchers cannot fully establish causes, and each suicide is different – it is especially hard to research suicide due to the inability to interview, question or study people after they have taken their own lives. Therefore, most of the data from which researchers can interpret meaning from is correlational, rather than causational.

This paper is a meta-analysis, meaning no field research has been carried out – rather, it uses the findings of other research studies to make comparisons, correlations and potential conclusions. This paper pulls together research studies and reliable sources on suicides in order to comment on what their potential causes, variations, and potential solutions might be. Therefore, the limitations around studying suicide apply to all of the research used in this paper. Furthermore, the majority of this paper serves as a traditional "results" section, as the intent is to analyze the work of other researchers.

Due to the negative connotations of the phrase "committing suicide," this paper will refrain from using this term, using terms such as "die by suicide" in its place.

The Sociology of Suicide

Many sociologists have attempted to explain what compels people to attempt suicide, and explain the different types of suicide. Emile Durkheim, an important sociologist in the emergence of sociology, had many thoughts on suicide and the sociological explanations for it, theorizing there are various different kinds of suicide [4]. One type of suicide, egoistic,

determines that some people may engage in suicide due to an isolation or alienation from their society, feeling they do not have a place within it. Commonly these people may be referred to as outcasts, or loners.

Another type of suicide is referred to as anomic suicide; these suicides are explained by a lack of stable structure within the person's social environment, which would otherwise give the person a sense of belonging and a meaning to life, such as religion or family. Durkheim saw anomie as being able to match or integrate with a group's system of social norms. Through many of Durkheim's theories on suicide, the main theme is that "the more thoroughly a person belongs, the lower the risk of suicide" [4]. This would suggest that social support networks, and close relationships with others, are some of the most important factors in preventing suicide.

Robert Merton elaborated on Durkheim's ideas of anomie, suggesting that it is a form of strain theory – the theory that society pressures people to commit deviant behaviors [5]. This would imply that suicide is the action people may take as a result of pressure from the inability to meet their goals; these goals are usually placed on a person by the society they live in, based on what is highly valued within a society or culture.

Within this paper, these sociological explanations, among others, will be examined and compared to try and describe and explain why certain aspects of society may lead to certain types of suicide.

Mental Health

The topic of suicide is commonly associated with depression, and other mental health disorders, which is understandable, as up to 60% of suicides are linked to major depressive disorder [6]. Figure 2 [7] shows a world map of depression rates, detailing that the United States is almost twice as depressed as South Korea, per 100,000 people. Why, then, are such high rates of suicide seen in a country like South Korea, which has such a low diagnosis of depressive disorders?

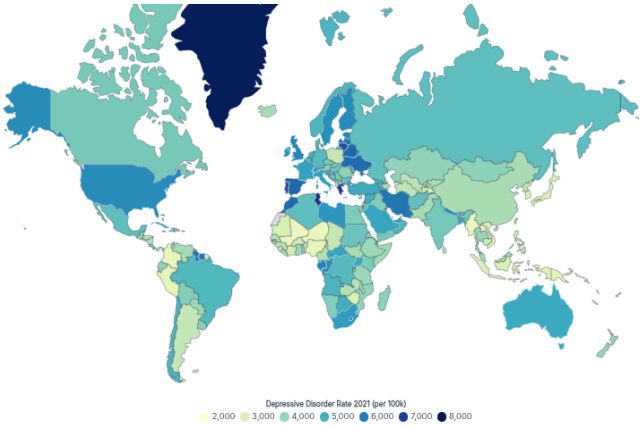


Figure 2: *A world map showing depression rates for each country per 100,000 people in 2021.*

This leads onto the first major sociological factor of suicide: stigmatization. In South Korea, symptoms of depression are still prevalent in the population, and yet the rate of diagnosis is low because of the stigma their society has placed on those with mental health disorders. Even when being tested for depressive symptoms via a questionnaire, it was found that South Koreans tend to respond with more socially acceptable answers and are less likely to acknowledge their own symptoms, hence their lower diagnosis rate [7], as they are overly self-conscious of what others may think.

Viewing depression (and its treatment) as shameful or weak has resulted in a lack of willingness to seek a diagnosis, out of embarrassment and shame, as people may not want to be labeled or seen as different. This supposed "shame" can be seen as a family shame, and a stain on a family's good name, which may lead to the family denying their relative's mental illness altogether, as has been commonly seen in China [8]. All of this discouragement may even lead their depression to worsen, therefore resulting in more suicides.

To choose to attempt suicide due to stigmatization – and being afraid to stand out as different in a negative way – could be argued as being an indirect contribution to altruistic suicide. If one believes they are bringing shame upon their family, or social group, their eventual suicide may be seen in their minds as necessary to stop themselves from disrupting the harmony or reputations of their social networks.

This can be contrasted with the societal attitudes to mental health in the United States, a country which actively encourages people to seek help with disorders such as depression – as do many Western cultures. While not entirely stigma-free, the U.S. is far more welcoming of those suffering with mental illnesses, as is reflective in many campaigns, and the significant amounts of Americans utilizing therapy, even though they may not suffer with depression. As a result of their advocacy for treatment and support, 61% of adult Americans diagnosed with major depressive episodes sought treatment in 2021 [9], whereas only 27.38% of South Koreans sought treatment or counseling for their diagnosed depressive disorders between 2017 and 2020 [10].

This is a difference that is consistent when comparing most Western countries against Eastern countries, as the stigma and lack of understanding or support for the mentally ill can be seen in China, Japan and India, among others. This may be due to the collectivist nature of these countries; since social image is of great importance to Asian cultures, people do not want to jeopardize their place within their societies or become shunned by others. Collectivism, as opposed to individualism, is the concept of interdependence and social harmony, putting a greater focus on the needs of a group, rather than those of an individual. Therefore, standing out as different from the majority is not necessarily a good thing in these cultures. The sociological concept of the looking-glass self – how people measure their own self-worth from the judgments of other people – relates to this severe stigma, as people in Eastern cultures appear to feel a greater shame from the judgment of others. Therefore, they do not seek help, for fear of being judged and losing "face."

Access to Healthcare

Stigmatization isn't the only thing preventing people from seeking treatment – being able to access necessary healthcare is a challenge in itself. In the United States, a lot of important and effective mental health resources require people to have health insurance, which can be costly, and may even rely on the client's employment status. Healthcare is not universal, or socialized, meaning those with lower socioeconomic status are in a worse position to receive adequate healthcare, both physically and mentally. In the United States, those who are uninsured have shown positive correlations with suicidal ideation and suicide rates than those with health insurance [11], with similar findings in China linking depression with a lack of insurance [12] – putting these people further at risk of becoming suicidal.

This is being seen in South Korea too; up until recently, mental healthcare was separate from primary care, which may have made it more inaccessible, as well as further enforcing the stigma surrounding treatment in South Korea. Despite the current lack of utilization of these services, there is no shortage of available mental healthcare in South Korea – people are seemingly unable or simply unwilling to use it. In late 2023, South Korea introduced a new plan to offer mental health checkups to young adults every 2 years, in hopes to address its high suicide rate issue [13]. With more emphasis on mental healthcare, especially after the COVID-19 pandemic of the early 2020s, there is a chance the stigmatization of mental illness can be lessened with this new generation of mental health-conscious young people.

Gender

It is not just international *differences* that should be considered here – there are plenty of societal factors that are near-universal internationally, such as the similarities in gender. In 2021, almost 4 in 5 suicides in the United States were by males [14], a trend mirrored in the United Kingdom with male suicide being three times as likely as female suicide [15], and again in South Korea with statistics finding men to be twice as likely as females to die by suicide [16]. Figure 1 helps to visually highlight these differences. The question is, why?

In the United States, women are more likely to attempt suicide than men, but men tend to use more violent methods, therefore successfully completing suicide more [17]. For example, 6 out of 10 gun owners in America are men [18], which may be a factor in this gender imbalance regarding suicide. Suggestions have been made that culturally enforced gender roles play a part in this, with women choosing non-violent methods in order to preserve their appearances [17]. It may just be that non-violent methods, such as overdosing, are simply not as effective at completing suicide, which is why women survive their attempts more than men do.

It is also theorized that men often use more violent methods because while women may be more likely to experience suicidal thoughts, men tend to have more genuine intent to die when attempting suicide. These findings are also seen in patterns within South Korea, as more females are admitted to the hospital from suicide attempts than males, yet more men actually die from their attempts. This is because while the most popular method of suicide is the same across genders in South Korea – ingestion of chemicals – men tend to use more harmful chemicals, in higher doses [19].

If there is truly more intent by men to die, why would men feel more willing to commit harder to these suicidal thoughts? Again, this may be linked back to stigmatization. While mental health support may be increasing in Western countries, there is still a stigma that men ought to "man up" when facing mental health issues, and tough it out; a stigma that is socialized onto boys from a very young age by previous generations, who didn't have anywhere near as much mental health support available as today in Western cultures. Men also tend to struggle more to talk about their emotions, and therefore find less social support as well as reaching out less often for medical help [15].

Because men find it difficult to reach out for help, they may turn to substances, or alcohol, for comfort. Men are twice as likely as women to meet the criteria for alcohol dependence in the United States [18], and alcoholism can increase the risk of suicide. The consensus varies, but statistics show that around 25-40% of suicide victims are found to have had alcohol in their systems at the time of suicide. Alcohol can also increase impulsivity [18], which is already stereotypically higher in males, and therefore might add to the suicide risk. Impulsivity is a characteristic highly associated with anomic suicide, as anomic suicide often comes from a sudden negative change of circumstances, which is also a leading cause for alcohol consumption. Therefore, it can be suggested that stigmatization and less social support makes the risk of death of suicide more likely in men globally, despite more suicide attempts being seen in women.

Collectivism

Many Asian cultures are collectivist, meaning that there is a priority placed on social harmony, and the success of a whole group, rather than each individual within it. Looking at Durkheim's theories, there are a few ways they can be applied here when questioning the differing suicide rates by country. Because South Korea is a collectivist culture, family ties are normally strong, which would suggest that collectivism plays no role here, as social support reduces the likelihood of suicide. However, a South Korean study [20] found that disturbances in family intimacy were the most powerful predictor of a suicide attempt among those who had depression, suggesting that perhaps collectivism emphasizes and increases the effects of a potential family dispute, making the family disturbance more upsetting and therefore increasing the likelihood of anomic suicide. Egoistic suicide, as described earlier, can be the result of being outcast or isolated from social support networks. Therefore a familial dispute, or even the end of a relationship or friendship, may be more likely to have this effect in a collectivist culture.

In collectivist cultures such as South Korea's, increased pressure is put on people to succeed from a young age, by parents, academia, and society [21]. Not only does this pressure affect young South Koreans' health by default, but it makes this much worse when things like grades, or social approval starts to slip. With poor grades, South Koreans find their career prospects waning and parental disapproval increasing, and this pressure would certainly seem to stop them from reaching their goals, which may apply to Merton's thoughts on anomie. In the United States, while academics and grades are still seen as important, there is less pressure or shame placed on a student should they fail to find success – school is not the be-all and end-all, as American culture encourages a range of alternative ways to be successful. Academic

excellence in the States is celebrated, but not necessarily expected, so the pressure and strain is not as high as that of countries like South Korea.

Because collectivist cultures seek to maintain order and social harmony, historically there have been examples of Durkheim's other named type of suicide, "altruistic," in which individuals self-sacrifice for the self-perceived betterment of the society they belong to. This may be most notably associated with Japanese culture, from which "kamikaze" and "seppuku" are terms famous even in Western culture. These are not common practices in modern times; however, according to a 2015 study, suicides in Japan masquerading as seppuku are still at a high level in modern times, despite it being an ancient samurai ritual [22]. Self-sacrifice for honorable causes is not something that Western culture has experienced much – unless we consider war to be suicide – but the West does still see it in acts of martyrdom, such as the self-immolation of pro-Palestine protester Aaron Bushnell in 2023.

Discrimination

Race and ethnicity represent one further sociological explanation for differing suicide rates. A trend seen in many cultures is that ethnic minorities tend to have a greater suicide risk, and this can be seen in both the United States and South Korea. Myung-Bae Park [23] found that within South Korea, adolescents with both parents born outside of South Korea had the highest rate of suicidal ideation out of all demographics, at 24.7%.

Sociological factors must be at play here, and there are a few key ones that come from racial discrimination – an aspect of sociological conflict theory, which focuses on inequality, and could be applied to the historical power struggle between white people and ethnic minorities in the United States. Of course, when discriminated against because of their race, people are likely to feel like outcasts, and isolated from the majority of their population. As previously discussed, social isolation and a lack of belongingness within a society is a potential explanation for egoistic suicide and can increase the risk of such. However, anomic suicide may instead be a better explanation for suicides influenced by racial discrimination, as institutionalized racism equates to a lack of consistent rules within a society that can leave a person feeling excluded – such as the inconsistent treatment of people within different racial demographics.

Another factor brought on by discrimination that may explain this trend is socioeconomic standing. As ethnic minorities in the United States have historically lacked equal access to housing, education, and career opportunities, there is an increased likelihood of poverty within these demographics, which acts as a cycle that is hard to escape from. Poverty, financial instability, and homelessness can also increase suicide risk [24]. All of these potential results of discrimination can also contribute to *further* discrimination, in the form of lacking quality healthcare, which as mentioned earlier in this paper can further increase suicide risk as there is less likelihood of being insured, or on a good healthcare plan.

Suicide brought on by socioeconomic discrimination would also be considered anomic suicide, as again it constitutes a disconnect from consistent social structures, witnessing the treatment of others and understanding them as different from one's own treatment, therefore feeling alienated by society. This would also relate to the concept of strain theory, as the

likelihood of the deviant act of suicide would be increased by something like poverty, due to a struggle to achieve the culturally valued goals of wealth and racial equality.

Climate

One might assume that bad weather could affect the suicide rate, with rain and gray skies feeling like an outward representation of the depression that might lead somebody to attempt to die by suicide. However, an unexpected similarity that seems to appear globally is that when the temperature increases, so do suicide rates. Cheng et al. [25] found that when the temperature in California increased by 1 degree Celsius, the expected suicide rate increased 0.83% when accounting for factors such as typical trends within the counties being studied. Warmer temperatures are associated with higher stress, irritability and impulsivity, which might account for this slight increase.

Similarly, Likhvar et al. [26] found that when temperatures in Japan increase, the suicide rate increases on that very same day. Likhvar et al. also discovered that this increase came predominantly from violent methods of suicide, finding that there was no significant change in the rates of non-violent suicide when temperatures increased. South Korea would also seem to follow this climate-based fluctuation in suicide rates, with a seasonal pattern showing peaks in spring, as temperatures began to increase, and troughs at the beginning of winter, as temperatures begin to decrease [27]. This may be because high temperatures are associated with physical and mental exhaustion, as well as negatively impacting sleep, all of which can have a negative impact on our mental health, making the risk of suicide more likely [28].

This can be considered a sociological issue, as climate change – an issue that affects all societies – can be seen as a contributing factor to this small but real effect of increasing temperatures. The increased risk of severe weather events, heatwaves, and overall global warming, may be an indicator that suicide rates due to climate factors are only going to increase in the coming years.

Methods of Suicide

Methods of suicide themselves can also be considered sociological – how a person chooses to end their own life can be reflective of their environments. In South Korea, the most popular method of suicide among 9-18 year olds is jumping from a high place [29], whereas in the United States, rather predictably, firearms were a leading method of adolescent suicide in 10-19 year olds [30]. Figure 3 [31], from the Center for Disease Control and Prevention, helps highlight the prevalence of firearm suicide among all American suicides in 2022, and Figure 4 [32] shows methods of suicide in South Korea across all age groups – notably missing a firearms section, due to its rarity.

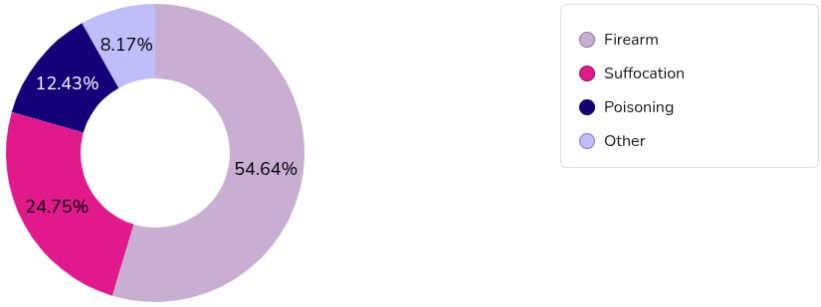


Figure 3: *The most utilized methods of suicide in the United States in 2022*

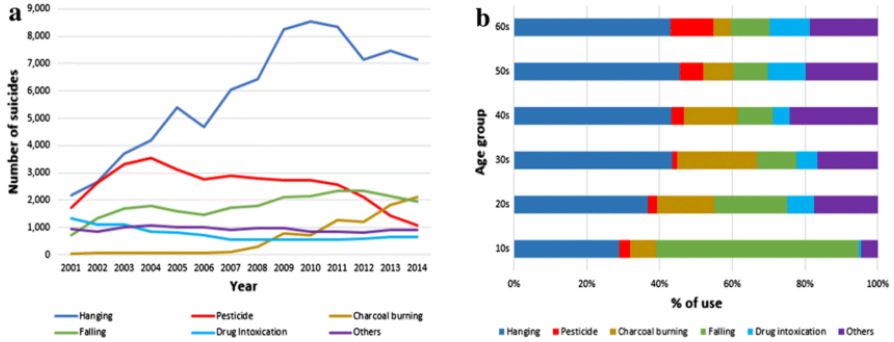


Figure 4: *The most utilized methods of suicide in South Korea, from 2001-2014.*

This would suggest that people use the methods that are more commonly accessible to them, since it is common knowledge that the United States has more guns than it has people, and South Korea is known for its tall apartment buildings due to the dense populations within its cities.

These findings lead us to a controversial but important issue among the United States; if people didn't have access to firearms, would the rates of suicide decrease, or would people with suicidal ideation just use other methods? It could be suggested that because death by firearm is considered 'painless', as it is quick and easy, taking this method away leaves few suicide methods that aren't extremely painful or slow, and therefore may discourage suicide in the United States.

It might be possible to speculate on why someone chooses a certain method of suicide, based on their motivation to attempt suicide in the first place. For example, should a person choose a quiet, less violent method such as hanging, this could reflect an egoistic intent – a lack of social networks and high isolation levels. Alternatively, anomic suicide often comes from a frustration at lack of social regulation, meaning these suicides may opt for more violent or public methods, partly due to the impulsivity of the decision, and partly due to their frustration towards the society that has failed them. Figure 4 shows that a large number of suicides in South Korea are made up of hangings; this might support the thought that social isolation in collectivist societies increases the likelihood of egoistic suicide.

Conclusion

Throughout this paper, many contributing factors have been discussed that seemingly correlate with suicide rates, leading to possible conclusions on how to lessen this serious issue. It seems that with acceptance, treatment, and an increase in mental healthcare, stigmatization around mental health issues can be reduced, which may in turn reduce depression and suicidal thinking. Societies also ought to put a focus on a sense of belonging, ensuring that people have social support groups or family to turn to in times of need, as Durkheim's theories of suicide relate to a lack of belongingness.

Both stigmatization and social support networks could be improved for those struggling with mental illness, especially when concerning suicidal men, which is gaining momentum in Western society with the support of mental health charities. Accessibility to fast and easy means of suicide, such as firearms, may also need to be assessed – especially for adolescents, who should not be able to access weapons and dangerous substances. Racial discrimination is hard to eliminate, but it is apparent that there are more issues from racism than appear at surface-level.

Again, it must be stated that the studies cited and research used is *correlational*, and only makes suggestions as to what may affect various suicide rates. Many people experience the difficulties discussed in this paper and choose not to attempt suicide, and may not even consider it in the first place. In contrast, many people die by suicide having not experienced the factors that this paper suggests would increase the likelihood of suicide. Suicide is hard to study due to a difficulty establishing clear motivations, and differs on a case-by-case basis.

There is clearly no easy fix to the suicide crisis, no matter which country is examined, but it seems that the world is coming together and starting to take action. More awareness of these issues is a great first step to tackling them, and one must appreciate that society has some changes to make. One thing is for certain: suicide is a global issue, no matter the international differences, and there will always be more work to do.

Acknowledgements

I would like to thank Professor Fleisher for his help and support on this project, as well as Dr. Cheryl Campo and everybody working at Schoenbrodt Honors, for allowing me to be a part of the Honors society and encouraging me to work as hard as I have across my time at HCC – I am very grateful for the opportunities and experiences that have come my way because of my involvement in this Honors program.

Contact: gsmith@howardcc.edu, gregsmith99afc@gmail.com

References

[1] World Suicide Prevention Day 2022. (2022). *World Health Organization.* https://www.who.int/campaigns/world-suicide-prevention-day/2022#:~:text=An%20esti

mated%20703%2C000%20people%20a,profoundly%20impacted%20by%20suicidal%20behaviours

[2] Suicide mortality rate (per 100,000 population). (2019). *World Health Organization.* https://data.who.int/indicators/i/16BBF41

[3] Fleck, A. (2024). Suicide rates around the world. *Statista.* *https://www.statista.com/chart/15390/global-suicide-rates/*

[4] Comer, R. J., & Comer, J. S. (2022). *Fundamentals of Abnormal Psychology* (10th ed., pp. 210-237). Worth Publishers.

[5] Zhang J. (2019). The strain theory of suicide. Journal of Pacific Rim Psychology, Volume 13, e27. https://doi.org/ 10.1017/prp.2019.19

[6] Chung, W. M. N., Choon, H. H., & Yin, P. N. (2017). Depression in primary care: assessing suicide risk. *Singapore Medical Journal.* https://doi.org/10.11622/smedj.2017006

[7] Lee, J., Kim, H., Hong, J. P., Cho, S. J., Lee, J. Y., Jeon, H. J., Kim, B. S., & Chang, S. M. (2021). Trends in the prevalence of major depressive disorder by sociodemographic factors in Korea: Results from nationwide general population surveys in 2001, 2006, and 2011. *Journal of Korean Medical Science*, *36*(39), e244. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8506416/

[8] Parker, G., Gladstone, G., & Chee, K. T. (2001). Depression in the planet's largest ethnic group: the Chinese. *American Journal of Psychiatry*, *158*(6), 857–864. https://doi.org/10.1176/appi.ajp.158.6.857

[9] Major Depression. (2023, July). *National Institute of Mental Health.* https://www.nimh.nih.gov/health/statistics/major-depression#:~:text=In%202021%2C%

[10] Lee, J., Choi, K. S., & Yun J.A. (2023) The effects of sociodemographic factors on help-seeking for depression: Based on the 2017–2020 Korean Community Health Survey. *PLoS ONE* 18(1): e0280642. https://doi.org/10.1371/journal.pone.0280642

[11] Tondo, L., Albert, M.J., & Baldessarini, R.J. (2006). Suicide rates in relation to health care access in the United States: an ecological study. *J Clin Psychiatry*. *67*(4):517-23. doi: 10.4088/jcp.v67n0402. https://www.psychiatrist.com/wp-content/uploads/2021/02/18010_suicide-rates-relation-health-care-access-united-states.pdf

[12] Tian, D., Qu, Z., Wang, X., Guo, J., Xu, F., Zhang, X., & Chan, C.L. (2012). The role of basic health insurance on depression: an epidemiological cohort study of a randomized community sample in northwest China. *BMC Psychiatry*. 20;12:151. doi: 10.1186/1471-244X-12-151 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3532421/#:~:text=The%20percentages%20of%20participants%20with,in%20the%20follow%2Dup%20surveys

[13] Park, J-H. (2023, December 5). South Korea unveils plan to tackle ailing mental health. *The Korea Herald.* https://www.koreaherald.com/view.php?ud=20231205000693

[14] Suicide data and statistics. (2022). *Centers for Disease Control and Prevention.* https://www.cdc.gov/suicide/suicide-data-statistics.html

[15] Kirk-Wade, E. (2025, January 8) Suicide statistics. *House of Commons Library.* https://commonslibrary.parliament.uk/research-briefings/cbp-7749/

[16] Yoon, L. (2023, November) Number of suicide deaths in South Korea from 2010 to 2022, by gender. *Statista.* https://www.statista.com/statistics/1267022/south-korea-suicide-deaths-by-gender/

[17] Freeman, D., & Freeman, J. (2015, January). Why are men more likely than women to take their own lives? *The Guardian.* https://www.theguardian.com/science/2015/jan/21/suicide-gender-men-women-mental-health-nick-clegg

[18] Schumacher, H. (2019, March 17). Why more men die by suicide than women. *BBC.* https://www.bbc.com/future/article/20190313-why-more-men-kill-themselves-than-women

[19] Hur, J. W., Lee, B. H., Lee, S. W., Shim, S. H., Han, S. W., & Kim, Y. K. (2008). Gender differences in suicidal behavior in Korea. *Psychiatry Investigation, 5*(1), 28–35. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2796090/

[20] Lee, J.-Y., & Bae, S.-M. (2015). Intra-personal and extra-personal predictors of suicide attempts of South Korean adolescents. School Psychology International, 36(4), 428-444. https://doi.org/10.1177/0143034315592755

[21] Hawk, W. (2023, March). Students in South Korea begin to value self-care amid academic pressures. *The Diamondback.* https://dbknews.com/2023/03/28/students-south-korea-self-care-academic-pressures/

[22] Pierre, J. M. (2015). Culturally sanctioned suicide: Euthanasia, seppuku, and terrorist martyrdom. *World journal of psychiatry*, *5*(1), 4–14. https://doi.org/10.5498/wjp.v5.i1.4 https://pmc.ncbi.nlm.nih.gov/articles/PMC4369548/#:~:text=Seppuku%2C%20the%20ancient%20samurai%20ritual,out%20both%20there%20and%20abroad

[23] Park, M-B. (2024). Suicide risk among racial minority students in a monoethnic country: A study from South Korea: Suicide risk among racial minority students. *Archives de Pédiatrie.* https://www.sciencedirect.com/science/article/abs/pii/S0929693X23001811

[24] Inequality and suicide. (2024). *Samaritans.* https://www.samaritans.org/about-samaritans/research-policy/inequality-suicide/#:~:text=People%20living%20in%20the%20most,is%20a%20major%20inequality%20issue.

[25] Cheng, S., Plouffe, R., Nanos, S.M., Qamar, M., Fisnam, D.N., & Soucy, J-P.R. (2021) The effect of average temperature on suicide rates in five urban California counties, 1999–2019: an ecological time series analysis. *BMC Public Health*. 21, 974. https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11001-6#citeas

[26] Likhvar, V., Honda, Y. & Ono, M. (2011). Relation between temperature and suicide mortality in Japan in the presence of other confounding factors using time-series analysis

with a semiparametric approach. *Environ Health Prev Med.* 16, 36–43. https://doi.org/10.1007/s12199-010-0163-0 https://link.springer.com/article/10.1007/s12199-010-0163-0#citeas

[27] Nam, H. J., Sim, H. B., Lee, J. Y., Kim, S. W., Kim, J. M., & Ryu, S. (2022). Changing Seasonal Pattern of Suicides in Korea Between 2000 and 2019. *Psychiatry Investigation*, *19*(4), 320–325. https://doi.org/10.30773/pi.2021.0387 https://pmc.ncbi.nlm.nih.gov/articles/PMC9058267/

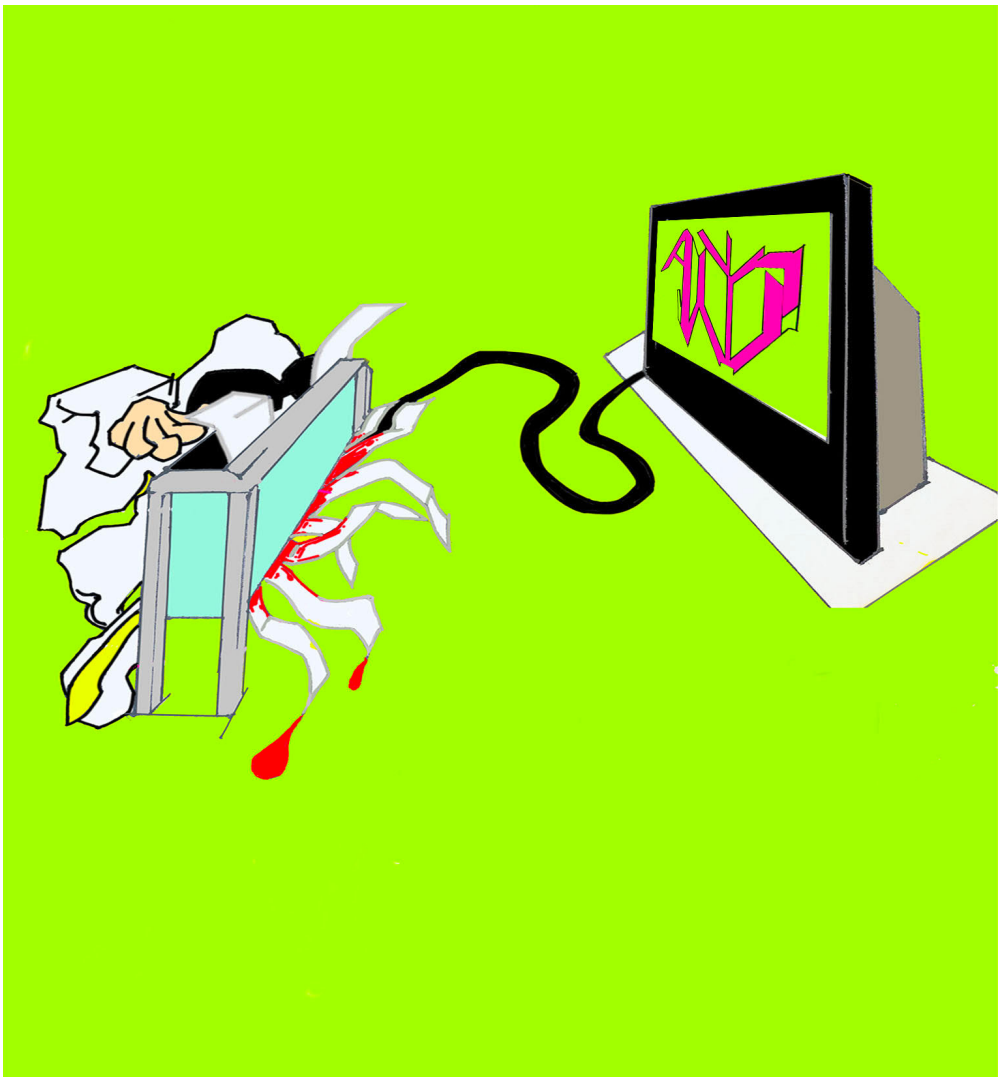
[28] Shoib, S., Hussaini, S. S., Armiya'u, A. Y., Saeed, F., Őri, D., Roza, T. H., Gürcan, A., Agrawal, A., Solerdelcoll, M., Lucero-Prisno Iii, D. E., Nahidi, M., Swed, S., Ahmed, S., & Chandradasa, M. (2023). Prevention of suicides associated with global warming: Perspectives from early career psychiatrists. *Frontiers in Psychiatry*, 14, 1251630. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10693336/#ref1

[29] Lee, M. S., Jhone, J. H., Kim, J. B., Kweon, Y. S., & Hong, H. J. (2022). Characteristics of Korean children and adolescents who die by suicide based on teachers' reports. *International Journal of Environmental Research and Public Health, 19*(11), 6812. https://doi.org/10.3390/ijerph19116812

[30] Ormiston, C. K., Lawrence, W. R., Sulley, S., Shiels, M. S., Haozous, E. A., Pichardo, C. M., Stephens, E. S., Thomas, A. L., Adzrago, D., Williams, D. R., & Williams, F. (2024). Trends in adolescent suicide by method in the US, 1999-2020. *JAMA Network Open*, *7*(3), e244427. https://doi.org/10.1001/jamanetworkopen.2024.4427

[31] Suicide data and statistics. (2024). *CDC*. https://www.cdc.gov/suicide/facts/data.html#cdc_data_surveillance_section_6-suicide-methods

[32] Kim, H., Kwon, S. W., Ahn, Y. M., & Jeon, H. J. (2019). Implementation and outcomes of suicide-prevention strategies by restricting access to lethal suicide methods in Korea. *Journal of Public Health Policy, 40*(16). DOI:10.1057/s41271-018-0152-x



“Shreds of Evidence”

Zachary Neiman
Pencil, Pen, Photoshop

I was drawn to the topic of Ethics and Legality of Generative AI in Journalism because AI is under heavy controversy and has been for some time now. At first, it was only aligned with cheating. Now it’s being heavily relied upon in society and is often represented in the media. In my piece, I created a scene where a character, caught using AI, attempts to destroy any evidence of their plagiarism by shredding themselves. This visual represents the idea that not only do they want to avoid legal and media scrutiny, but they also realize that they can’t hide their guilt unless they destroy themselves entirely. The glitch on the screen alludes to AI’s limitations in producing the same depth of work as human creativity.

The piece started as a pencil drawing, which I photographed and imported into Photoshop. I used the line tool to trace the image and add color. This method allows me to keep the creative freedom of traditional paper while achieving the clean appearance of digital art. Through this piece, I want to communicate the importance of trusting one’s own creativity and intellect, rather than relying on AI for artificial shortcuts. The takeaway is to value original thought and have the courage to create with your own mind, without resorting to automated help.

Ethics and Legality of Generative AI in Journalism

Lucas Eaton, *Howard Community College*
Mentored by: Bethany Pautrat, M.A.

Abstract

Journalism is a field that has persisted throughout ages of technological advancement and has become ever more accessible and efficient throughout the centuries. News journalism has a responsibility to deliver accurate, up to date, impartial information to its consumers. With the advent of generative Artificial Intelligence (generative AI) tools that can automatically create text, audio, images, video, and other forms of media based on a written prompt, journalistic institutions have been forced to adapt. This paper will analyze the breadth of uses for generative AI in news journalism, the opinions of industry groups on generative AI, expert opinions on the copyright status of and use of generative AI, and the ethical codes of news companies with the goal of finding in which circumstances generative AI tools are legally and ethically acceptable for use in the workflows of these news companies.

Introduction

Generative AI tools are machine learning programs that have the ability to create and modify various forms of media, including text, images, video, and audio [1] automatically based off of a written "prompt" describing what the user wants the generative AI program to output [2]. These outputs are based off of data, such as text or images, that the generative AI program is "trained" on in order to create a human-like response mimicking patterns in its training data [1]. Generative AI systems are already used in some fashion across the journalism industry, being used for everything from writing stories to summarizing research [1] to translation. The Associated Press, one of the largest institutions in journalism, has been using AI tools for "automatically generating" stories about corporate earnings since 2014 [3], and in 2023 made an agreement with OpenAI, the creators of popular generative AI tool ChatGPT, to essentially trade a license for part of the AP's enormous text archive for OpenAI's "technology and product expertise [4]." It is apparent at this point that, barring unforeseen circumstances, generative AI has received industry approval and is here to stay.

However, despite their increasingly common use in researching stories, compiling data, writing, and other parts of the journalism workflow, the implementation of these tools in the journalism industry is a controversial topic. Its unrestricted use faces opposition from journalism-related industry groups such as Reporters Without Borders (RSF) and the National Writers Union (NWU), experts in the AI and journalism fields, and various news companies.

When it comes to generative AI, RSF is mainly focused on ensuring that AI tools are truthful, accountable, and safe [5], whereas the NWU is more focused on protecting the livelihoods and rights of writers it represents [6]. Experts are concerned about the ethics of feeding people news that AI has had a hand in creating, the copyright status of AI generated works, and if these machines can be trusted to provide factual, reliable information. The New York Times, Washington Post, USA TODAY, CNN, the Associated Press, and various other companies all have standards restricting their own use of generative AI tools in some way [7, 8, 9, 10, 11]. However, none of these organizations rule out its use as a whole, with the AP proudly displaying its history of using AI tools for its journalism efforts on a dedicated web page [3]. Despite all these concerns, the industry seems intent on embracing, or at least accounting for, this generative AI future.

This paper attempts to analyze, compare, and contrast the opinions and actions of these news companies and industry organizations on the use of and effects of generative AI on the journalism industry. In addition, it analyzes expert interpretations and analysis of copyright law and the ethics of the use of generative AI systems for journalists to come to a conclusion on the ethics and legality of the use of generative AI for journalistic purposes. Additionally, it offers an example of a theoretical generative AI model that would satisfy the requirements of all of these organizations.

Methodology

This paper employs a review of prior research on the ethical considerations of using generative AI tools in journalism, the copyright status of the outputs of generative AI tools, and the legal and ethical status of AI training data. In addition, it employs articles from the National Writers Union (NWU) and Reporters Without Borders (RSF) on the topic of generative AI. Finally, it uses a review of the ethical guidelines set by individual news organizations in the use of generative AI. It takes the opinions and actions of all of these parties into consideration and seeks a conclusion on what uses of AI in journalism are acceptable and which uses are not.

Ethical Overview from the Perspective of Experts

A computer cannot be held accountable. It is generally agreed upon that the unrestricted, blind use of generative AI tools in journalism is an unwise decision. Fears of misinformation, copyright issues, the ethical sourcing of AI training data, and more permeate the writings of scholars in the field. However, many also agree that AI tools can be ethically used in one form or another in news journalism, even if the industry needs to amend its values of accuracy, impartiality, and accountability [5], with one paper saying that the use of generated AI for journalism "…challenges traditional conceptions of journalistic practice and necessitates the development of new ethical standards [1]." Despite these concerns, the industry has begun to use these tools in numerous ways.

A large area of concern is the possibility of AI created misinformation being published by news sources that people consider dependable. Writers Shi and Sun [1] claim that generative AI is a threat to the credibility, accuracy, and quality of journalism, and others agree, with Noain-Sánchez [12], who interviewed a collection of experts in the field, noting that the

interviewed experts "…place especial emphasis on the role of the human journalist as an irreplaceable agent and as the professional that must supervise AI outputs…," viewing AI tools as fallible and viewing it necessary to fact check its outputs to prevent misinformation, which AI tools will often write with complete confidence. These experts consider AI tools to be imperfect, but believe that their upsides, such as being very efficient at crunching data, outweigh their downsides. They consider them just another tool to augment the ability of human journalists rather than a true replacement due to this possibility of misinformation. They also generally agree that writers and editors must keep an eye open for incorrect information, even if an AI tool is being used to compile and sift through data rather than write independently.

Tomlinson, Patterson, and Torrance [13], writing for The San Diego Law Review, bring up fears of purposeful information. They consider the possibility of the training data the AI bases its outputs on being purposefully skewed to push an agenda or produce purposeful misinformation, claiming that "Any biases, inaccuracies, or malicious alterations that are present in the initial dataset, or introduced into the training set… have the potential to compromise the integrity and trustworthiness of the AI model." A biased training set, whether done accidentally or on purpose, could lead to news articles being created that omit certain information. This could be difficult to catch by conventional fact checking, as it may not be technically wrong, just missing part of the full story. The authors also consider that biased training sets could cause AI-generated news to disproportionally focus on topics that paint certain groups in a bad light, saying that "An AI-generated news summary might disproportionately focus on crime stories involving specific racial or ethnic groups if the training data overrepresent such stories, perpetuating harmful stereotypes and misconceptions [13]." AP is already piloting using AI to generate summaries of its articles [3], so organizations creating AI generated summaries of the news in general may be commonplace soon. This is an issue that would need to be solved by AI companies themselves, and journalists and the organizations they are a part of would need to choose their AI tools carefully to avoid these kinds of issues. However, several AI companies, including OpenAI and Google, claim to make attempts to avoid these issues. OpenAI claims that they "…teach our AI and implement filters to help prevent it from generating biased and harmful outputs [14]." Google says that they are "Employing rigorous design, testing, monitoring, and safeguards to mitigate unintended or harmful outcomes and avoid unfair bias [15]." In theory, this should mean that at least with these specific companies' AI models, the fears of these authors should not be an issue, though OpenAI and Google are careful not to rule out the possibility, just say that they attempt to avoid it. This further proves the point of Shi and Sun that writers, editors, and readers all need to focus on fact checking in the age of AI journalism, as it is difficult to truly avoid all misinformation when AI is involved [1].

Copyright Overview from the Perspective of Experts

Another perspective that experts have focused on is the legal status of AI generated works and the AI models themselves. As current US copyright law does not consider AI generated news copyrightable material, there is a push for it to do so. If that initiative is successful, it could have far-reaching consequences in the journalism space. In the United States, copyright is not granted to any work not created by a human [16]. This means that presently, it is difficult in the United States to copyright a work generated by an AI model. An example of this is the rejection of copyright is seen with two different AI generated artworks, one with an AI

listed as the only author and one with an AI listed as a co-author, both rejected for the reason above. Kuai [16], explains the reason this is as: "...in protecting human creative work as a practice, all copyright laws uphold the anthropocentric value of insisting on originality and creativity. This could potentially put automated news in a legal quagmire since the fact-based nature of news and the journalistic pursuit of factualness may come at odds with being 'original' or 'creative'." Essentially, Kuai is saying that this idea of copyright as a method for protecting the work as a human would mean that for the output of, for example, an AI chat bot to be copyrighted, it would need to be recognized as the work of either the person who typed in the prompt that led to the output, or some other party.

In "Blurring the lines: how AI is redefining artistic ownership and copyright", authors Watiktinnakorn, Seesai, and Kerdvibulvech [17] state that based on a survey of legal professionals, creative professionals, and others, "humans and machines are now collaborators in the creative process. As a result, both parties involved rightfully deserve recognition and protection under copyright laws." If this concept becomes the new standard of copyright, it could have a major impact on the use of AI in journalism. News companies may be less likely to heavily use AI tools if they are unable to copyright the contents. This idea is not without opposition. The authors found that "Among the eight individuals engaged in art production, a unanimous sentiment emerged, stressing the necessity and critical importance of enacting legal regulations to govern AI. They emphasized that the ramifications of AI directly impact their professions [17]." These ideas, though professed by artists, can be assumed to carry over to many other creative professions, including journalism. If the writers ideas are reflected in law, their fears may lead to the continuation of the status quo when it comes to copyrighting AI generated works. On the other hand, the legal professionals surveyed believe that there should be exceptions in copyright law to favor the use of these technologies [17]. If this does happen, it could lead to an explosion of AI generated news, though if news companies follow the prior advice of experts and keep a close eye on the outputs of their AI tools, they may be unable to increase throughput as much as would otherwise be possible. However, even if these exceptions are implemented, it is uncertain if AI generated news would even be a copyrightable work due to its pursuit of factualness over being original and creative [16]. This would make the entire copyright conversation irrelevant in terms of the news media unless it is decided that AI generated news is a creative work in the same way AI generated artwork would be.

The beliefs of the legal experts interviewed by Watiktinnakorn, Seesai, and Kerdvibulvech on the copyrightability of AI works are not without theoretical backing. O'Callaghan, writing for the Cornell International Law Journal [18] claims that the USA follows a philosophically utilitarian approach to granting copyright, granting it based on what would maximize the economic incentives to create. O'Callaghan [18] follows this up by arguing that AI systems, despite not needing economic incentives to create works, do need economic incentives to be created in the first place by AI companies. The author says that due to this, allowing AI generated works to be copyrighted would have a trickle-down effect to the creators of the AI model, as the people using the AI would be able to justify spending money on it due to being able to take advantage of the fact that they can copyright the outputs created by the AI. This would fulfill the idea of economic protection as a reason for copyright. It is of note that this argument does assume that generative AI companies should be economically incentivized to create their models in the first place. The author also includes arguments against the idea of

needing economic advantages, acknowledging that there are those who believe that AI companies do not need that extra help, as they already have enough economic advantages. One example they give is that the AI systems themselves are already protected under intellectual property law. [18]. If these generative AI outputs are considered copyrightable, AI companies would have various advantages immediately. There is less human input needed for their outputs compared to traditional writing and research, creating a competitive advantage for AI tools over human journalism, where multiple people can be on the payroll to write one article. In this case the AI tools would be competing with human staff for "jobs," and AI companies would have a market in companies looking to decrease their labor costs. This would have enormous consequences for journalists.

The final realm of copyright for AI is the use of copyrighted works of training sets, which is the set of data, such as websites, books, articles, images, and other material that the AI bases its outputs on. Spica [19] argues that based on legal precedent and how generative AI functions, the use of copyrighted works for training generative AI falls under the fair use doctrine. She does, however, believe that "…creators still have a valid copyright infringement claim against individuals claiming authorship over AI-generated output that exhibits a substantial similarity to the creator's copyrighted work." In short, her conclusion is that whatever the AI is trained on does not matter as long as its output is not "plagiarizing" the works on which it was trained. Only the output matters, not the source. On the one hand, this idea means that journalists would not be able to get compensation for the works of theirs that are trained on by AI companies. On the other hand, they would be able to reasonably assume copyright for anything they create using generative AI tools, assuming it is in fact not too similar to a preexisting document, making it a more valid tool for doing serious work. This would also mean that there is even more of an incentive to proofread AI outputs, as they would need to ensure that the AI outputs are not too close to existing works in addition to fact checking.

Positions of Industry Groups

Various groups relevant to journalism have taken stances on the use of AI in the field. One of these groups is Reporters Without Borders (RSF), an international non-profit with the goal of promoting freedom of information [20]. They have published, in collaboration with other organizations, the *Paris Charter on AI and Journalism.* A second group is the National Writers Union (NWU), which represents and advocates for journalists, authors, and other writers in the United States. They have published their *Platform and Principles for Policy on Generative AI* on their website, taking a position in defense of the livelihoods of the authors [6]. Both of these documents make a statement about the use of generative AI and provide guidance on its use while forwarding the respective organizations' goals.

Reporters Without Borders intends the charter to be a guide to journalists and companies worldwide when using AI in journalism. They make it clear with the first principle that AI cannot change the core values of journalistic ethics. They quickly corroborate the necessity of accuracy stated by Shi, Sun [1], and others, along with the necessity of unbiased outputs of Tomlinson, Patterson, and Torrance [13], stating that the use of generative AI cannot mean the rolling back of ethical standards of accuracy, non-discrimination, and impartiality [5]. In addition to this, they make it clear to the reader that "media outlets are always responsible for the content

they publish" and that the media needs to be transparent about where and how AI was used [5]. When it comes to the AI systems themselves, they believe that AI systems employed by the media should be evaluated by the media company and third parties to ensure that they adhere to their standards of journalistic ethics, and that they need to "respect privacy, intellectual property and data protection laws [5]." Another important part of this charter is that RSF believes that people and organizations involved in journalism should be "included in any global or international institutional oversight of AI governance and regulation [5]." As journalists are some of the people whose creations have the largest reach and influence that would have a reason to be using AI tools, along with having a major stake in how they collect and output information due to copyright and ethical issues, it makes sense to include journalists perspectives in these conversations. The final important part for this charter is one that is not popular among AI companies. The charter states that "AI system owners must credit sources, respect intellectual property rights, and provide just compensation to rights holders. This compensation must be passed on to journalists through fair remuneration. AI system owners are also required to maintain a transparent and detailed record of the journalistic content utilized to train and feed their systems [5]." Generally, AI companies treat all information on the internet as if it is freely available and theirs to use as training data [6]. RSF does not consider this the case. They want the people who own the content AI is trained on to be fairly compensated for their work, and for AI companies to be transparent about their use of specific "journalistic content" for training [5]. Overall, they want a better deal for journalists in the age of generative AI while keeping them accountable for what they create using those tools. To summarize, they want to allow the use of AI if and only if it is used ethically by their standards.

The National Writers Union (NWU) is an organization which seeks to protect its members before all else. The NWU makes both ethical and legal statements in support of their generally negative stance on AI within this document [6]. They view of AI as a threat to their livelihood and role in their field, with one of the first passages stating, "As generative AI technologies expand to displace human creators of almost every type of copyrighted work, we must remember not to leave any creative worker behind." The NWU [6] views generative AI as a force that must be mitigated and agrees with many of the aforementioned authors that generative AI cannot be used without a human element. With this organization's opinions added to the pile, we begin to see a consensus forming on the use of generative AI in the creation of news reporting. The NWU shares a fear of biased training data with Tomlinson, Patterson, and Torrance [13], saying that "generative AI reproduces, and sometimes enhances, pre-existing social inequities and biases such as racism, sexism, homophobia, transphobia and more [6]." They do not provide any solutions for preventing these issues when using generative AI tools, only including them as an acknowledgement of the fact they exist. RSF's [5] advice on evaluating AI systems before using them would help prevent these issues.

Many of the authors whose ideas are considered in this paper only considered misinformation and copyright on the output side of the generative AI equation. NWU, in its goal to protect writers, also considers the sourcing of the training data for these AI models. They claim that "Generative AI works because it 'ingests' voluminous amounts of human-made creativity – the work of millions of human lives – which should be protected from exploitation and erosion. On this issue, even more than in other copyright debates, our humanity matters [6]." This is a call to action from a moral stance rather than a legal one, introducing the idea that AI

companies should not have free reign to use whatever they want for training AI models. This is a sentiment echoed by RSF [5] and others, and is clarified in a later sentence: “Right now, generative AI companies are benefiting handsomely from algorithms they’ve trained on millions of pieces of our work that they haven’t paid a cent for, even though without the work of creators as input, these systems would not work at all [6],” introducing the core of their argument. They believe that the use of their creations as training data without consent is tantamount to theft, and they want to be compensated both for the ingestion and the continuous usage of the content [6]. This is at odds with the thoughts of Spica [19], who concluded that the use of copyrighted material for training AI falls under the fair use doctrine. The NWU specifically petitions for the government to, either through law or statute, declare using copyrighted content for AI training not free use. This is a logical conclusion for the NWU, as even if others have concluded that it is fair use, it is the job of the NWU to advocate for its members.

When it comes to the authors own use of AI, The NWU [6] also agrees with the RSF [5] that AI generated content should have a transparent dataset but go a step further and say that the output of the AI should provide attribution to training data used as “sources” for the output. In addition, they agree with the RSF and other experts that AI generated content must be labeled as such. Once again, a consensus begins to form in the industry. Generative AI outputs used in journalism must be fact-checked, unbiased, and labeled as AI generated content as to ensure they are not misleading the reader on the nature of both the content itself and the information within, whether unintentionally or otherwise.

One thing that industry experts, groups representing journalists, and scholars can all agree on is that the AI cat is out of the bag, and there is no putting it back. The NWU states that, “Where we cannot protect jobs from displacement by AI, we must ensure that we’re providing pathways to safe, just, and accessible economic opportunities [6].” They, just like all other parties, have concluded that AI here to stay and they must adapt to the best of their ability. They now need to race to get the best possible outcome for themselves, as trying to avoid it all together will result in a greater loss for themselves than embracing it where they can and fighting it where they feel they need.

NYT vs. OpenAI

In December 2023, the New York Times Company filed a lawsuit against OpenAI, the creator of ChatGPT, along with Microsoft, of its largest investors. The suit alleges that OpenAI illegally used its copyrighted works when it trained its AI [21]. The case has yet to be decided as of January 2025. However, it shows that the NWU [6] is not alone in its view that non-consensual AI training is theft. In addition, the Times’ claims are in certain ways supported by the ideas of O’Callaghan [18] and Spica [19]. The NYT claims that due to the ability of these AI tools to reproduce content very similar to the Times’ articles, these generative AI products are causing financial harm to the Times by providing access to its reporting without paying the Times for the content [21]. As reported by NPR [22], an OpenAI lawyer has stated that the infringement the Times refer to only happened after “’thousands of tens of thousands’ of queries. In essence, [The OpenAI Lawyer] argued that the publishers primed the chatbot to spit out text that was lifted from the publishers' websites [22].” If true, this would mean that the Times’

claims of too-similar reproduction are not as applicable in the real world as they want you to think, which could reduce the credibility of the New York Times' arguments.

However, if they can do it, that means, in theory, anybody can, effectively circumventing the New York Times' paywall. If it is possible and reproducible, it is an actual issue, and an infringement of copyright despite the use of the training data itself being fair use as asserted by Spica [19] essentially meaning the New York Times Company wins unless OpenAI finds a way to prevent that entirely, or possibly enough that it is inconsequential. O'Callaghan [18] argues that AI companies need a financial incentive to make generative AI products, and claims that making it possible to copyright AI generated material would provide that incentive due to increased commercial activities. The NYT turns this on its head by claiming OpenAI's use of its copyrighted works damages its business by reducing its financial incentive to produce its content [21] under the utilitarian United States copyright philosophy. In theory, due to this idea OpenAI's ability to use their copyrighted works without payment would constitute a loss to the "economic value of creativity and innovation [18]" of the Times, and possibly provide a reason to create an exception to the fair use doctrine in the case of AI training as requested by the NWU [6], as it could shift the playing field between OpenAI and the New York Times in a way that promotes the more original, creative endeavors of the NYT.

Present Uses of Generative AI in Journalism

AI has been used for over a decade in the news industry, with the first widespread use of it for published pieces being the aforementioned case of the Associated Press automating the creation of financial reports. However, the organization has since extended its efforts to use AI into other applications, including, as of the ninth of December 2024, automating sports writing, video transcriptions, and timestamping videos. Additionally, AP is working on both using it to follow trends on social media and using it for image recognition [3]. Though AP is the company that advertises its use of AI most heavily, other major publications are not ignoring the possibilities that AI brings with it. The New York Times [7], Washington Post [8], USA TODAY [11], CNN [10], and FOX [23, 24] all are either known to use generative AI, or, (with the exception of FOX), have considered the possibility enough to publish the standards surrounding its use in their newsrooms. Due to its self-admitted heavy use of AI compared to what other media outlets advertise, AP will be the company to which other companies AI use and policies will be benchmarked in this paper, along with the industry groups.

The Associated Press [3], in addition to its page explaining how it uses AI tools in the newsroom, has two pages on AI ethics. Near the top of their code of ethics, they state that "the central role of the AP journalist – gathering, evaluating and ordering facts into news stories, video, photography and audio for our members and customers – will not change. We do not see AI as a replacement of journalists in any way [3]," and specify that despite their use of AI, they are still committed to their previous ethical standards and have not lowered them to promote the use of AI. They have a strict stance on the publishing of AI generated content, saying that "Any output from a generative AI tool should be treated as unvetted source material [3]." As AI tools do not necessarily "know" where their outputs come from, this is an understandable policy, especially when accounting for the fears of misinformation presented by various scholars in the field [1, 13]. AP also treats AI generated imagery as per the guidelines of industry experts,

including the RSF [5], stating that they will not use "AI-generated images that are suspected or proven to be false depictions of reality [3]," only making an exception for if the topic of the news story is the image itself, in which case they will label it as AI generated. This policy is one that is agreed upon by the industry at large and follows the ideas behind principle three of the *Paris Charter on AI and Journalism* [5]. Overall, the only part of the RSFs guidelines on the journalism itself that is not stated in APs guidelines is principle three, which requires that "AI systems used in journalism undergo prior, independent evaluation [5]." It is expected that the Associated Press, one of the largest news agencies in the world, would want to follow these guidelines as closely as possible to preserve its reputation in the age of AI, while not missing the opportunity to strengthen and optimize its own operations.

Despite its lawsuit against OpenAI, The New York Times Company [7] states that "Machine learning already helps us report stories we couldn't otherwise, and generative A.I. has the potential to bolster our journalistic capabilities even more." This suggests that the NYT is currently using AI in its reporting in some fashion. They do not elaborate on what stories AI is helping them report that they could otherwise not. However, the Times does establish what they believe are benefits to its audience, saying that "The Times will become more accessible to more people through features like digitally voiced articles, translations into other languages and uses of generative A.I. we have yet to discover [7]." None of these use cases for AI are out of the ordinary and are possibly not as prone to misinformation compared to writing articles or doing research with generative AI. When it comes to the standards they hold themselves to, The Times claims that they must only use AI "With human guidance and review [7]," stating that "Generative A.I. can sometimes help with parts of our process, but the work should always be managed by and accountable to journalists [7]." This concept of strict human oversight is corroborated by the opinions of the RSF, along with Shi and Sun [1]. Overall, the New York Times follows the same track as The Associated Press, just without the advertising of what it specifically uses AI for, such as APs writing of headlines. Just like AP, they want to have the opportunity to use AI in their operations while maintaining their reputation and credibility.

CNNs [10] guidelines are fairly similar to those of AP and the NYT, stating the familiar commitments to transparency and accuracy. They say that they will, "clearly signify to our users and audiences when they are seeing, hearing or reading AI content [10]," matching the RSFs guidelines on disclosing the use of AI [5]. When it comes to accuracy, they state both that they are committed to accuracy in their journalism and that they have human oversight and guardrails for AI. Though they are not as specific as other organizations on what kind of oversight and guardrails they have, they do state that their "…employees have oversight and responsibility for the AI systems and tools used, and the content they produce [10]." This, in theory, would put them in line with expert recommendations for fact checking. They do not state specific processes, but CNN [10] does say that they hold their employees accountable for AI generated content, which would presumably lead to a similar effect to the more specific guidelines of other companies if enforced. CNN does take one step further than many of its peers and the RSF [5] when discussing AI however, saying that they are "committed to fair representation and diversity [10]." This, depending on the interpretation, could help them counter fears that generative AI tools could produce information biased against certain groups due to flawed training data [13]. If their writers and editors are keeping an eye out for a lack of, "…fair representation and respect for diversity…[10]" when "…utilizing innovative technologies such as AI tools and services

[10].” If these guidelines are followed, they could catch more obscure issues of bias due to their employees enforcing this policy than they would if they were just checking responses for pure misinformation. Overall, CNNs policies around the use of generative AI are largely in line with the recommendations of the RSF [5], though, as with the others, they do not specifically state that they follow the third principle of the Charter and will only use AI tools have been independently evaluated. However, they do state that “We undertake rigorous due diligence to evaluate our internally built tools and potential partners to ensure they adhere to both CNN and Warner Bros. Discovery’s AI principles [10],” suggesting that they do perform their own investigations into the AI tools they use. Though not exactly the same as what the Charter recommends, it is a step above using tools of unknown credibility.

The Washington Post [8] has fairly similar published policies to the above outlets. They say they will be transparent about AI, not attempt to pass off realistic AI generated images, video, or visual works without disclosing its use, and verify any information sourced from AI tools [8]. The specific wording of “Employ AI to generate images, video or visual works that purport to represent reality [8]” leaves open the possibility of using AI to generate imagery that does not purport to represent reality without labeling it as AI generated.

USA TODAY [11] has guidelines akin to those of other news outlets for the use of AI tools, though their published policies appear intended to be used by their employees themselves in addition to being read by third parties and have more specific wording than the policies of some of their peer organizations. They have similar ideas of fact checking AI generated content and not treating it as a source. However, they go a step further than certain other outlets and say that they do “…not use AI-generated photo-realistic images in our news coverage [11].” Some news outlets, such as AP [3] have not gone as far, and allow it with disclosure under specific circumstances. In addition to this, similar to CNN [10], they attempt to be representative and diverse in their reporting when using AI. However, USA TODAY and specifies that AI generated content in particular must not “discriminate against any individual or group based on race, ethnicity, religion, gender, sexual orientation, or any other characteristic [11].” This is a much more specific stance than the one taken by CNN, which simply states, “We are committed to fair representation and diversity [10],” and puts USA TODAY, based on published policy, at the top of the list when it comes to outlets that may share Tomlinson, Patterson, and Torrance’s fears of biased data sets [13]. If USA TODAY is specifically looking out for biases in AI generated content in addition to misinformation, they would be the most resistant of all of these companies to training set manipulation, hindering the possibility of it causing biased results towards or against one group or another showing up in articles.

Several trends form across these outlets’ policies when compared to the recommendations of RSF [5]. All the AI use guidelines require at some level that AI generated content be checked for factuality, matching with the recommendations of principles two and four of the Paris Charter on AI in Journalism. Most of these outlets additionally require AI generated content to be labeled as such, especially if it is an image, fitting with principle five, and to an extent, principle seven. The only one of these outlets that explicitly rules out realistic looking AI generated imagery in line with principle seven is USA TODAY [11]. Other outlets either only rule out doing it when the image is not a part of the news itself, (such as AP [3]), or simply do not mention AI generated imagery as a discrete concept. Outlets attempt to keep the door open

for the use of non-realistic AI generated images, which does not violate the recommendations of RSF [5]. However, looking at the debate ethically, use of AI generated imagery may be considered immoral by the NWUs demands of compensation for the creators of the works used to train AI models [6]. Another principle not followed by all media outlets is principle three, which recommends that "AI systems used in journalism undergo prior, independent evaluation [5]." Most of these media companies do not state that they review the tools they use for "adherence to the core values of journalistic ethics [5]." Though it can be assumed that the outputs would be screened for violations to the codes, this is a step that is missing from the policy pages of many major outlets. Overall, the majority of major news outlets in the United States analyzed in this paper are mostly aligned with the recommendations of Reporters Without Borders.

Further Discussion And Conclusions

Generative AI has taken the journalism world by storm over the past several years, and just about every organization has adapted its operations and policies to this new paradigm. There are growing conflicts between journalists and others in more creative disciplines, the organizations that employ and represent them, and the AI companies who are at the forefront of bringing AI tools to the masses – and to the journalists themselves.

The alignment of news agencies in the United States to the recommendations of scholars and its own industry groups is not exact. One guideline that the grand majority of the major news outlets included in this paper can agree on is that, as suggested by Shi and Sun [1], they needed to update their codes of ethics to account for AI generated content. In general, these organizations adopted similar ideas to those suggested by Reporters Without Borders [5]. The New York Times, The Washington Post, USA TODAY, CNN, and The Associated Press have published promises to at some level label AI generated content as such, and fact check AI generated content in line with RSF recommendations. Only USA TODAY explicitly forbids the use of realistic looking AI generated imagery in all circumstances as recommended by RSF. Most other organizations have looser limits on their ability to publish AI generated realistic imagery. However, there are gaps in the AI policies of these companies. A minority of these organizations claim to specifically attempt to avoid bias and discrimination in AI outputs. Even if these concepts are forbidden elsewhere in an ethical code, as humans are not writing AI outputs, extra care must be placed into verifying there are no biases inherent in AI generated or assisted works. Additionally, many organizations do not state in their published ethical codes that they are using independently evaluated AI tools, putting them again at odds with RSF guidance, and furthering the risk of data set manipulation, which can lead to tainted, biased outputs.

The final two principles of the *Paris Charter on AI and Journalism* are in part related to the ongoing conflict of interests between AI companies and journalists. AI companies want free reign over their models and free use of any data they can gather, regardless of licensing. Organizations such as the National Writers Union and Reporters Without Borders both advocate for AI companies to credit the sources of the data they use to train AI models, (which includes news reporting), and compensate the rights holders of that data. AI companies claim that their use of news as training data falls under fair use in the United States, which is why The New York Times Company has sued OpenAI and Microsoft for using its reporting to train AI without

consent, and the outcome of this case will most likely be the deciding factor on whether journalists will ever get the compensation and rights they believe they deserve. The case is far from decided, however Spica [19] believes that the case will fall in favor of OpenAI, preventing journalists from getting the compensation their representative organizations believe they deserve. Despite this, it may not be exclusively bad for journalists as Spica, along with other experts, believe that although currently AI generated works are denied copyright in the United States due to the lack of a human author, provided the output of a generative AI tool is sufficiently original, the law may end up shifting to favor the people behind an AI generated work. This would be beneficial to news organizations, who would otherwise have more difficulty copyrighting news created with AI assistance than they would have with human-written content.

Despite the industry at large following the ethical guidance of the experts, there are still gaps that should be filled. Any news organization that does not have a published code of ethics or policies in relation to AI should publish one for the sake of transparency. Accountability is also important, being included in principle one of the *Paris Charter on AI and Journalism*. As a computer cannot be held accountable, the people who create, edit, and publish works created in conjunction with generative AI tools must be held accountable for misinformation, bias, or other issues with the work, even if they were created by the generative AI tool. In addition, many of these news organizations do not specify how, if at all, they screen AI tools before beginning to use them. Publishing this information is a next step that would further the credibility of AI assisted news writing and help catch issues with a model's factuality and bias before putting them into action in the newsroom. This would also help prevent the effects of data set manipulation, by ideally catching issues before they start and allowing outlets with concerns about bias and discrimination in their AI outputs to check for them ahead of time. This could benefit the news companies materially too by reducing the probability of needing to rewrite or re-research a news piece due to issues caused by a flawed, discriminatory dataset.

Another possibility to help prevent the issue of misinformation and biased data sets is proposed by Dierickx et al [25]. These authors believe that a method to keep AI tools aligned with the goals of accurate, fair, and transparent journalism would be by making them smaller, more specialized, and more carefully made. By better vetting the data that goes into the models to prevent misinformation from being trained on in the first place, combined with developers following their framework for designing AI tools, they believe that journalists could more confidently and safely use AI tools in their work. All of this would also bring the outlets more in line with the guidance of the RSF, who prioritizes, accuracy, fairness, and transparency. The consensus of the industry is that there is no concrete ethical or legal reason as of the present day to not use AI in journalism, if, and only if, the outputs are vetted properly. The ethics and legality of training off unlicensed data, however, are still being debated.

Creating a model following the Open Source Initiative's (OSI) [2] definition of open source AI, while also only using licensed data, would be a theoretically concrete way to create a truly transparent and fair AI model and is possibly the most universally ethical approach. The OSI requires that information on what data was used to train the model, along with where and how to obtain it, be publicly available [2]. This would help with transparency and theoretically make it easier for third parties to look for issues with bias in the training data. In combination with all training data being properly licensed, the model would be aligned with the opinions of the NWU and RSF on the matter of proper compensation for the rights holders of the training

data, transparency, and non-discrimination. A model created under these conditions would not be guaranteed to only create factual outputs. Despite this, due to the transparency of the training set, it would be easier to find root sources of misinformation.

The discussion around the use of AI in journalism is rapidly developing. Journalists, AI companies, and institutions are all still figuring out their place in this new world. AI companies and writers are in conflict over the ethical sourcing of training data, and the copyrightability of AI generated works is a subject of contention. As these groups fight for their interests, laws and concepts of ethics may shift. However, in a field as important as journalism, it is important that ethical guidelines are upheld as much as humanly possible. Though it is yet to be fully seen to what ends generative AI tools, journalists, and the law will adapt themselves to suit the other, a few things are clear. Fact checking of AI outputs, and transparency when using them, is necessary. Journalism needs to continue to be a reliable, impartial, source of information, and most major institutions claim to be committed to this. Without these things, AI generated journalism cannot be trusted, but with them, there is no concrete reason not to.

Further Research

After the New York Times' lawsuit against OpenAI and Microsoft is decided, some of the speculation in this paper will be outdated, but I believe more opportunities will open up for research in their absense. In the future, researchers could examine the real world practicality of smaller, more focused models for journalism as suggested by Dierickx et al, and examine exactly what it would take, technologically and financially, to create a functional real world AI model that satisfies both journalists and AI companies. Additionally, future research could be done into how to compensate the the rights holders of data used to train AI, and how much to fairly compensate them for.

Acknowledgements

I would like to thank Bethany Pautrat and the rest of the HNUR staff involved in the Rouse Scholars Program for their mentorship and support, and for convincing me that this was a topic worth writing a paper about.

Contact: lucas.eaton@howardcc.edu

References

[1] Y. Shi and L. Sun, "How Generative AI Is Transforming Journalism: Development, Application and Ethics," Journalism and Media, vol. 5, no. 2, pp. 582–594, Jun. 2024, doi: https://doi.org/10.3390/journalmedia5020039.

[2] Open Source Initiative, "The Open Source AI Definition – 1.0," Open Source Initiative, 2024. https://opensource.org/ai/open-source-ai-definition

[3] “Artificial Intelligence,” The Associated Press. https://www.ap.org/solutions/artificial-intelligence/

[4] The Associated Press, “AP, Open AI agree to share select news content and technology in new collaboration,” The Associated Press, Jul. 13, 2023. https://www.ap.org/media-center/press-releases/2023/ap-open-ai-agree-to-share-select-news-content-and-technology-in-new-collaboration/

[5] Reporters Without Borders, “RSF and 16 partners unveil *Paris Charter on AI and Journalism* | RSF,” rsf.org, Nov. 10, 2023. https://rsf.org/en/rsf-and-16-partners-unveil-paris-charter-ai-and-journalism

[6] “Platform and Principles for Policy on Generative AI,” National Writers Union, 2023. https://nwu.org/issues-we-care-about/generative-ai/ (accessed Feb. 13, 2025).

[7] S. Dolnick and Z. Seward, “Principles for Using Generative A.I. in The Times’s Newsroom,” The New York Times Company, May 09, 2024. https://www.nytco.com/press/principles-for-using-generative-a%E2%80%A4i%E2%80%A4-in-the-timess-newsroom/

[8] The Washington Post, “Policies and Standards,” Washington Post, Jan. 01, 2016. Accessed: Feb. 13, 2025. [Online]. Available: https://www.washingtonpost.com/policies-and-standards/

[9] N. Meir and The Associated Press, “Standards around generative AI,” The Associated Press, Nov. 22, 2024. https://www.ap.org/the-definitive-source/behind-the-news/standards-around-generative-ai/

[10] CNN, “ABOUT CNN DIGITAL,” CNN, Feb. 28, 2014. https://www.cnn.com/about (accessed Dec. 08, 2024).

[11] USA TODAY, “USA TODAY NETWORK Principles of Ethical Conduct For Newsrooms,” Usatoday.com, Dec. 04, 2023. https://cm.usatoday.com/ethical-conduct/

[12] Noain-Sánchez, “Addressing the Impact of Artificial Intelligence on Journalism: the perception of experts, journalists and academics,” Communication & Society, vol. 35, no. 3, pp. 105–121, Jun. 2022, doi: https://doi.org/10.15581/003.35.3.105-121.

[13] Tomlinson, D. J. Patterson and A. W. Torrance, "Turning Fake Data into Fake News: The AI Training Set as a Trojan Horse of Misinformation," The San Diego Law Review, vol. 60, (4), pp. 641, 2023.

[14] OpenAI, “Safety & responsibility,” openai.com, 2024. https://openai.com/safety/ (accessed Dec. 08, 2024).

[15] Google, “Google AI Principles,” Google AI, 2023. https://ai.google/responsibility/principles/ (accessed Dec. 08, 2024).

[16] J. Kuai, “Unravelling Copyright Dilemma of AI-Generated News and Its Implications for the Institution of Journalism: The Cases of US, EU, and China,” New Media & Society, vol. 26, no. 9, pp. 5150–5168, Aug. 2024, doi: https://doi.org/10.1177/14614448241251798.

[17] Watiktinnakorn, J. Seesai and C. Kerdvibulvech, "Blurring the lines: how AI is redefining artistic ownership and copyright," Discover Artificial Intelligence, vol. 3, (1), pp. 37-10, 2023.

[18] O’Callaghan, "Can output produced autonomously by AI systems enjoy copyright protection, and should it?: An analysis of the current legal position and the search for the way forward," Cornell International Law Journal, vol. 55, (4), pp. 305-350, 2022.

[19] E. Spica, “Public Interest, the True Soul: Copyright’s Fair Use Doctrine and the Use of Copyrighted Works to Train Generative AI Tools.,” Texas Intellectual Property Law Journal, vol. 33, no. 1, pp. 67–91, Sep. 2024.

[20] Reporters Without Borders, “Who are we?,” Rsf.org, Jan. 22, 2016. https://rsf.org/en/who-are-we#rsf-is-2846

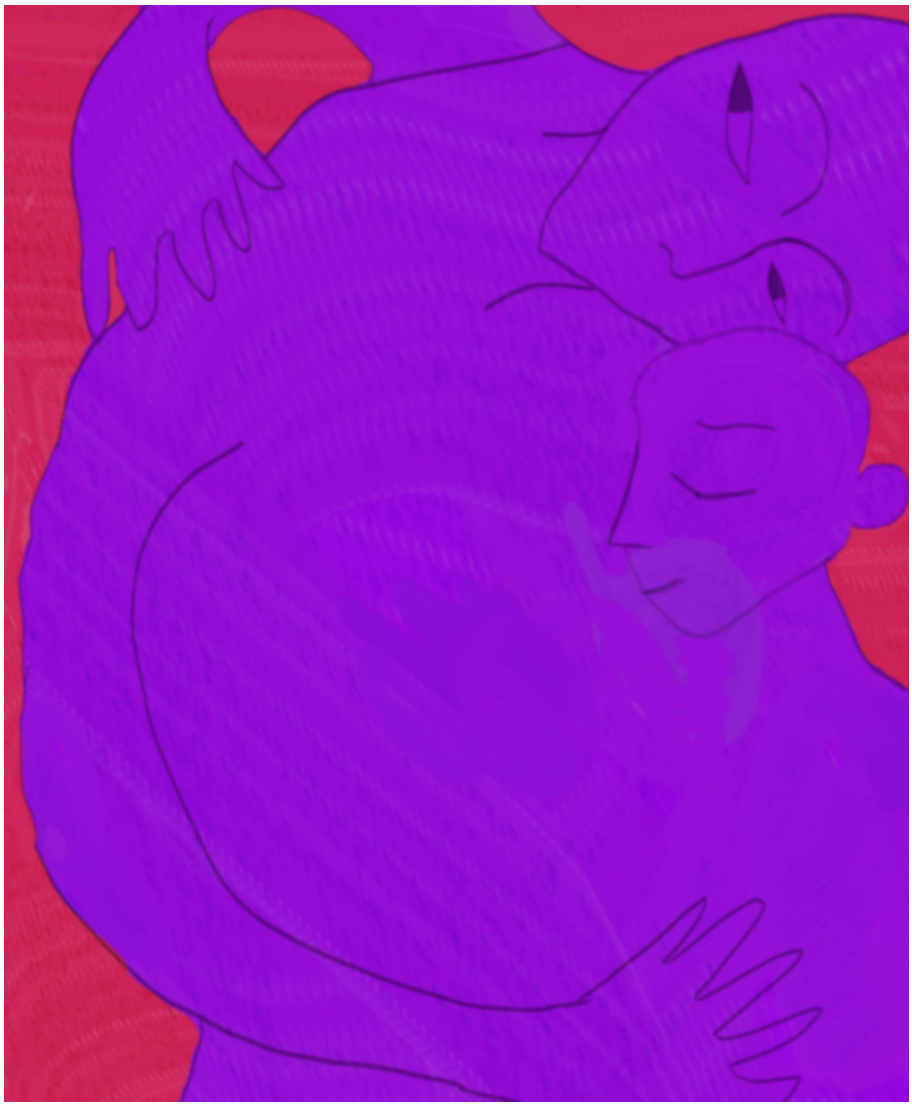
[21] A. Pope, “NYT v. OpenAI: The Times’s About-Face,” *Harvard Law Review*, Apr. 10, 2024. https://harvardlawreview.org/blog/2024/04/nyt-v-openai-the-timess-about-face/

[22] B. Allyn, “‘The New York Times’ takes OpenAI to court. ChatGPT’s future could be on the line,” *NPR*, Jan. 14, 2025. https://www.npr.org/2025/01/14/nx-s1-5258952/new-york-times-openai-microsoft

[23] FOX, “Business Ethics,” *FOX*. https://www.foxcorporation.com/corporate-governance/sobc/business-ethics/ (accessed Dec. 08, 2024).

[24] “FOX Corporation Uses AI to Change the Face of Media | AWS Summit New York 2023 video | AWS,” *Amazon Web Services*, 2023. https://aws.amazon.com/solutions/case-studies/fox-summit-ny-2023-keynote/ (accessed Dec. 08, 2024).

[25] L. Dierickx et al, "A data-centric approach for ethical and trustworthy AI in journalism," Ethics and Information Technology, vol. 26, (4), 2024.



"Together"

Max Gears-Leverknight
Digital Art

I was drawn to this topic as it relates to the idea of a genderless society and the benefits that could result from the destruction of the barriers used to separate us by sex and gender - a freeing concept for me. I used digital tools as I have access to a variety of built-in brushes and could experiment with different materials very easily – my main coloring brush, for example, was a brush meant to replicate the texture of oil paint, which would have been difficult physically. The colors are purposefully chosen to align with the themes of the piece and the writing – the genderlessness of these abstract beings. Purple is a mix of blue, associated stereotypically with boys, along with red, which pink, a traditionally 'feminine' color, is a shade of. I wanted these figures to omit gendered characteristics, only the bare necessities to be able to decipher the piece.

Ursula K. Le Guin and George Wilhelm Friedrich Hegel: Gender Connections in *The Left Hand of Darkness*

Nikki Kreizel, *Howard Community College*
Mentored by: Timothy Bruno, Ph.D.

Abstract

Using the framework of Hegelian dialectic to understand the author Ursula K. Le Guin and her science fiction novel The Left Hand of Darkness*, connections can be drawn to the gender hierarchy in society. Through analysis of the novel's language, the history of the First and Second Waves of Feminism, and Hegel's dialectic, I was able to conclude that a society without traditional gender hierarchy can be successful, peaceful, and prosperous. Such a society, as is conceptualized in* The Left Hand of Darkness*, can be used to rethink our society's harmful gendered hierarchy. This research offers a shift in traditional binary thinking to highlight a diverse perspective of the framework and narrative through which one views their own life.*

Introduction

A popular science fiction novel, *The Left Hand of Darkness* by Ursula K. Le Guin is a revolutionary tale on gender written in a time of Second Wave American feminism in the 1960s. The novel is an early attempt at exploring the possibility of a society not defined by its own social hierarchies. Through understanding the historical period, the author, and the content of the novel, one can begin to understand the ideological shift needed for change to occur on a broad societal scale. Looking beyond the concept of gender itself, I will explore the notion of *The Left Hand of Darkness* as a classic Hegelian novel and of Le Guin as being a classic Hegelian thinker. In exploring these ideas, one can consider the relationship of Hegel's dialectic thinking to feminism, Ursula K. Le Guin, and the effectiveness of *The Left Hand of Darkness* in questioning the worth of gender binary in creating a peaceful, unified society.

A revolutionary of her time, Ursula K. Le Guin published the science fiction novel *The Left Hand of Darkness* in 1969. In the mid to late 1960s, literature exploring the controversial ideas of feminism and gender was relatively rare. Literature of this time did not explore the realms of what was possible in a society that had been so characterized by a binary, heteronormative view of gender and its function, or, in other words, a society shaped by

heterosexual relationships and clear divisions between male and female gender. Le Guin played a role in shifting this narrative with her science fiction novel. In *The Left Hand of Darkness*, she explores what a society lacking in gender binary might look like – whether it could be more successful, more adept at peace and unity, than a society in which gender hierarchy defines life. Through a comparison of the novel's alien character, Genly Ai, and his journey to become recognized as a fellow creature worthy of attention, the novel's journey can be used to rethink the notions of acceptance in society today.

First Wave of Feminism

To begin making sense of the issues being dealt with in the novel, it is first necessary to understand the historical context of feminist movements in the United States. The First Wave of Feminism took place in the 19th and late 20th centuries, with goals of gaining social and constitutional rights to put women on equal ground with men. Most notably, the First Wave of Feminism achieved passing the 19th Amendment to the United States Constitution, allowing women the right to vote in U.S. politics. While this was a big win for women at the time, it still was an unequal win and a wholly unequal movement. In large part, feminist work of this time centered around the rights of "white, Western, middle-class women," at the exclusion of most others [2]. Furthermore, women were not seeking to leave behind the binary-gender, unequal state of American social hierarchy. In keeping with the status quo, the patriarchal system of binary gender was widely seen as adequate and even desired to maintain order and function within society. As history progressed, however, women sought to gain more rights and more recognition for their role in the home and in the workplace [3]. However, this was still not a push for equality between genders or an abolishment of the gendered system itself, but it was a way women could move around more easily and visibly within their seemingly designated roles in society. The move towards this way of thinking eventually erupted into the Second Wave of Feminism, which began in the 1960s.

Second Wave of Feminism

Ursula K. Le Guin was a product of the Second Wave of Feminism. This was a political movement of recognition, acceptance, and integration of women into the general affairs of society. Previously, women had been viewed as mothers, as housewives: as a role to fulfill and play. Feminist movements sought to have women recognized for their physically laborious housework, the emotional labor of their marriages and childrearing, and their unequal place in the workforce [3, 4]. In Le Guin's surroundings, white middle-class women were fighting for equality in the workforce, equal pay, and to be recognized as more than just a "reproductive creature" to be used by men [3]. It is from this period and from this perspective that Le Guin wrote her science fiction tale of gender and of the journey towards recognition and acceptance of an alien species of people. The parallels between the feminist movement of her time and the depictions of gender in the story are remarkable. As the main character, an alien creature to the Gethenian people, Genly Ai's journey of acceptance by the society and his subsequent push for the joining of a confederation of planets mirrors the feminist movement. His journey was similar in its move for recognition, acceptance, and social integration.

Diversity in Feminist Movements

While the Second Wave of Feminism was far more successful than the First Wave in creating awareness for women's issues and removing women from their silent jobs as mothers and houseworkers, the movement did have faults. Feminist activism of the 1960s was essentially feminism fought for the white, middle-class, educated woman [2]. Additionally, the movement mainly focused on women who were married to men and who had children of their own. The Second Wave did not consider women of any other race, sexual orientation, or marital status. In fact, those women were still pushed out of any attempt to participate in sit-ins or protests to further the feminist agenda [5]. Beyond just the comparisons of the Second Wave of Feminism and the novel itself, feminism of the '60s had faults that feminists of today have continued to address.

This knowledge prompts readers to question the diversity of these movements. Since the Second Wave, women who have not fit into these limited social categories have often been excluded and even harmed by the feminist movements themselves. Where could every other woman who did not and does not meet this image fit into society? Where could such a woman find support, encouragement, and solidarity in community? The feminist movements of today seek to rectify and answer these questions. A study conducted at the University of Michigan found that intersectional invisibility harms already marginalized Black women in a two-fold manner, finding themselves at the intersection of racism and sexism [5]. In another show of the current feminist issues, transgender women, or women assigned male at birth, also find themselves in the crosshairs of inequality. To reconcile the issue of women's rights for trans women, Emi Koyama, a social justice activist, seeks a solution in transfeminism. She sees the transfeminist movement as a "movement by and for trans women who see their liberation to be intrinsically linked to all women and beyond" [6]. Representing only two such perspectives, questions of feminism are clearly at odds with each other, with the movements themselves, and with the general attitudes of Western societies.

The Left Hand of Darkness

In attempting to decipher such a complex issue, Ursula K. Le Guin offers a novel shift in thinking. In her book, Le Guin presents a society unmarred by the complexities of gender, by the constant push and pull that Western societies face in the movement towards liberation and freedom for men and women. Le Guin offers a thought experiment, a proposed idea or solution to the issue of gender in a patriarchal world. In essence, she asks: in a world plagued by the scars of patriarchal history and present-day traumas, how might society look if gender being defined as Man versus Woman was removed from the equation and replaced by a society where gender existed as Ambisexuality, as a totality of both and neither gender? This question is exactly what lays the foundation for Gethenian society and its ambisexual people.

In the fictional society on the planet Gethen depicted in the novel, male and female do still exist as conceptual ideas, appearing relevant for short times. In general, however, the Gethenian people live in a sexless and genderless state, called *somer*, in which they are "sexually inactive, latent." Every 22 or 23 days, however, during the period of *kemmer*, sexual potency

comes alive. As it is described, "the sexual impulse is tremendously strong in this phase, controlling the entire personality, subjecting all other drives to its imperative" [1, pp. 96-97]. A Gethenian has an equal chance of being a Man or a Woman, mostly in the sense of genitalia rather than in behavior. While binary gender does exist during this short period, one can argue that it is not entirely binary, given that each individual has an equal chance of being either gender at any given period of time. In their notes on Gethenian sex, Ekumenical researcher Ong Tot Oppong writes, "Normal individuals have no predisposition to either sexual role in *kemmer*; they do not know whether they will be the male or the female, and have no choice in the matter." Oppong further points out that much leeway and freedom is given to Gethenians during the period of *kemmer*. It is a time of intense sexual, emotional, and physical relationship with others. It is also the time when pregnancy may occur for any Gethenian if they are given the female sex organs. This being the case, all have equal leniency in work, responsibility, and life, a leniency not afforded to pregnant mothers in our Western society [1, p. 99]. Le Guin shows Gethenian life as such:

> "The fact that everyone between seventeen and thirty-five or so is liable to be 'tied down to childbearing,' implies that no one is quite so thoroughly 'tied down' here as women, elsewhere, are likely to be – psychologically or physically. Burdens and privilege are shared out pretty equally, everybody has the same risk to run or choice to make. Therefore, nobody here is quite so free as a free male anywhere else." [1, p. 100]

Because all Gethenian people exist free of desire for sexual interaction during most of their lives, they live with intense focus and goal-oriented behavior. They are not distracted by desire, by emotions, by the push and pull of a gendered experience. Life on Gethen is peaceful, is fair, is equal in its inequality. Gethenians prioritize work, compliance, and survival in their everyday lives. Sexual escapades and the mental distractions of desire have no interference in the general order of life.

If it is the case that Gethenian society is generally a peaceful place to live and its people do not suffer the usual fate of gendered hierarchical society, one must consider the relationship of these two factors. Without the pressures of gender, of patriarchal control, life appears far simpler and more peaceful. Death and punishment for crimes are left up to nature. Without the biological urge to procreate, to constantly seek sexual partners, life is focused and equal. In their comical quip, Oppong exclaims, "One is respected and judged only as a human being. It is an appalling experience" [1, p. 101]. Our society is vastly different – different in the sense that personal judgement comes from the perceived ability to parent, one's financial accomplishments, and the ability to meet the unfair expectations that a binary gendered society places upon its members. If such respect and peace is the case on the fictional planet of Gethen, can this idea be extended to the reality of life on Earth – to life in a society centered around the inequalities and expected roles of gendered hierarchy?

Hegelian Dialectic

To answer such a question, one must understand and use the principle of Hegelian dialectic. Classic Hegelian writing can be viewed through a trinomial lens – a three-part perspective melding oppositional ideas into a cohesive third conclusion. This idea of thinking in

threes is commonly called dialectic. In essence, dialectical thinking is a contradictory process of opposing sides, of viewing opposite sides of an issue. Other dialectic methods of thought can commonly lead to a philosophical standstill, making it impossible to form a conclusion based on the oppositional ideas and viewpoints. This leads to either a skepticism of the issues themselves or a sense of nothingness – a giving up in the face of seemingly no conclusion. Hegel shifted the common two-sided viewpoint to include a third component in his three-part philosophical perspective. In his view, there are two opposing viewpoints, called "thesis" and "antithesis." The thesis is an intellectual proposition, while the antithesis is the negation of the thesis, or the disbelief in the commonly held belief. To come to terms with these oppositional ideas, Hegel introduces synthesis, a third component unifying the oppositional ideas into a new perspective. To Hegel, the dialectic process creates a "new concept but one higher and richer than the preceding—richer because it negates or opposes the preceding and therefore contains it, and it contains even more than that, for it is the unity of itself and its opposite" [7]. In this sense, Hegelian dialectic is a philosophical framework allowing for the eventual synthesis of ideas into the creation of something new, rich, and intellectually gratifying.

It is with this understanding of the Hegelian dialectic that one can begin to answer broad questions of meaning. As a framework of thinking, Hegel's dialectic allows for the understanding of gender though the framework of a synthesis. Gender, in this case, can be thought of as a "What if?" question framed through three parts. What if Man versus Woman, as is seen in a gendered binary, takes second place to the synthetic notion of a comprehensive Ambisexual state, as seen in the novel? As a synthetic idea, an ambisexual state can be viewed as a bisexuality, or attraction to both genders; as a sexual ambiguity; and/or as unisex, or suitable for both Man and Woman [8]. In this way, ambisexuality is not a negation of gendered binary, but is a state of totality, encompassing the binary into a unified third, or a synthesis. It is this synthesis that allows for the consideration of whether a gendered framework in society is needed or beneficial. Readers might wonder what goal the gender binary serves in a society of vastly diverse people. Thinking through Hegel, the answer to this appears to be that the idea of Man versus Woman is itself a social construct offering little value to the real picture of society.

In comparing the Gethenian ambisexuality and the world where Genly Ai comes from, with its gendered hierarchy, Ai contemplates the significance of the gender binary. In this comparison, he comes upon a conundrum of questioning the dualities themselves. As Ai says:

> "I suppose the most important thing, the heaviest single factor in one's life, is whether one's born male or female. In most societies it determines one's expectations, activities, outlook, ethics, manners – almost everything. Vocabulary. Semiotic usages. Clothing. Even food. … It's extremely hard to separate the innate differences from the learned ones. Even when women participate equally with men in the society, they still after all do all the childbearing, and so most of the child-rearing… But it isn't that they're stupid. Physically they're less muscular, but a little more durable than men." [1, pp. 252-253]

It is with this thought that readers see the issues of a binary logic. As Ai explains the ways in which gender is performed in his world, he appears to question why roles are divided as they are. In his reasoning, males and females mainly differ on the expectations put upon them by the gendered society in which they live, rather than by any inherent difference. As Ai considers the

gendered characters in his society, he comes to question why the hierarchy exists and what function it is designed to play. If Ai can start to question this inequality and way of life, can the notion be extended and applied to human life?

Finding the Connections

Consider for a moment that Le Guin wrote her novel as a science fiction set in a fictitious place far away from the current realities of human society. Science fiction allows for the writing of nearly any ideas, framed in whatever manner, whether somewhat close to reality or completely imagined and impossible. To draw the bridge between this fiction and any real-life application is best done with Hegel's dialectic. Without the framework of Hegelian thought, it would be difficult to determine the conclusion that a third alternative of ambisexuality does, in fact, offer a richer existence than the current state of society, in which life is centered on the binary of gender.

The importance and relevance of the relationship of Hegel to a science fiction novel should be thus considered. According to some, such a question and its resulting answer are of little importance. Why consider a science fiction novel with its fictitious problems when people today struggle with real issues? Society today, as was the case throughout history, struggles with hierarchies, including hierarchies of gender, race, social status, and income, to name a few. Why, then, is it important to consider a made-up world and its made-up problems? To answer this question, readers must consider Le Guin's own words. In an interview, Le Guin pointed out that she had no intention of her novel ever being a model for which people might want to follow. Rather, she had intended for the tale to be a thought experiment, a method through which to view a particular issue affecting real people in the real world. Le Guin explains, "Everybody was asking: 'What is it to be a man? What is it to be a woman?'... I eliminated gender to find out what was left" [9]. This view is not a negation of gender by a removal of the notion itself, as an antithesis would suggest; rather, this idea offers a synthesis in which the concept of a hierarchy is expanded in favor of a more equal perspective. With this knowledge, one can see how a thought experiment has great power in prompting a mindset shift. The idea of an ambisexual society, replete with its ways of life and relative peace, can be superimposed on the current gendered society on Earth. It is evident that when not confined to a binary state of existence, or a hierarchy where people are seen as lesser or greater based on their gender, a society can function in a state of relative peace. Man versus Woman is not necessary to maintain order and rule within a society. Seeing the evidence of this in a fictional novel gives an idea and a hope to those living inside the bounds of such a world. This idea can be used to implement change and action in the current binary world. What could life on Earth look like if binary gender roles were pushed aside, allowing for greater social movement within society?

Conclusion

In wrapping up a paper on the relationship of gender, Hegel, and *The Left Hand of Darkness*, one should consider the question: How might society look if gender as Man versus Woman was removed from the equation and replaced by a society where gender existed instead as ambisexuality, a totality of simultaneously both and neither gender? If the long-fraught history of the feminist movements in the United States is any indication, our world has struggled to

make peace in an inherently unequal society, in which gender is placed on a pedestal and allows for a patriarchal system to be perpetuated. While some might consider it a far reach, Le Guin's science fiction novel allows for a view into a theoretical possibility and somewhat abstract thinking, a thinking that allows for the use of science fiction to inform real-life understanding and action. By using the novel's truly Hegelian dialectic reasoning, it is possible to see how a society shifted away from Man versus Woman offers an entire world of possibility as a society of ambisexuality – of both and neither. Hegelian thinking clearly opposes the negative thinking or either-or, of this-or-that. Le Guin masterfully escapes these ideas by offering her readers a synthesis of the two – an entire planet of people who are not ruled by their own binary but by the tertiary of ambisexuality. Sometimes Man, sometimes Woman, but usually what she calls "potentials, or integrals" [1, p. 101]. Thus, to answer the stated question: society without Man versus Woman could look like the Gethenian society of peace, prosperity, and justice in its equality.

Acknowledgement

I would like to express sincere gratitude to my professor and mentor, Dr. Timothy Bruno, for his guidance and encouragement throughout this writing process.

Contact: nikkikay101@gmail.com, tbruno@howardcc.edu

References

[1] U. K. Le Guin, *The Left Hand of Darkness*. New York, NY, USA: Penguin Random House, 1969.

[2] M. Rampton. "Four Waves of Feminism." Pacific University Oregon. Accessed: May 13, 2024. [Online.] Available: https://www.pacificu.edu/magazine/four-waves-feminism.

[3] C. Tsoplakis. "Comparing and contrasting the Women's Rights Movements from the 1960's to today." Accessed: May 8, 2024. [Online.] Available: https://www.google.com/url?sa=t&source=web&rct=j&opi=89978449&url=https://journals.psu.edu/ne/article/download/61055/60773/65765&ved=2ahUKEwju5a7-q8eFAxU1F1kFHYJ2BQoQFnoECBgQAQ&usg=AOvVaw0jytK19O_qg_oWRXHO5uJS.

[4] "Second Wave Feminism: Collections." Gale.com. Accessed: May 13, 2024. [Online.] Available: https://www.gale.com/primary-sources/womens-studies/collections/second-wave-feminism.

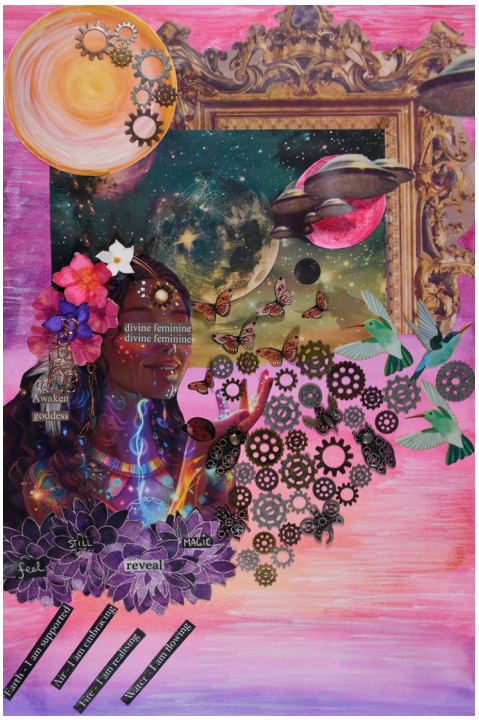
[5] S. M. Coles and J. Pasek, "Intersectional invisibility revisited: how group prototypes lead to erasure and exclusion of Black women," *Transl. Iss. In Psych. Sci.*, no. 6, pp. 314-324, 2020, doi: 10.1037/tps0000256.

[6] T. Bettcher, "Feminist perspectives on trans issues," Stanf. Encycl. Philos. Accessed: Feb. 4, 2025. [Online.] Available: https://plato.stanford.edu/entries/feminism-trans/#TowTra.

[7] J. E. Maybee, “Hegel’s dialectics,” Stanf. Encycl. Of Phil. Accessed: Feb. 4, 2025. [Online.] Available: https://plato.stanford.edu/entries/hegel-dialectics/#ApplHegeDialMethHisArgu.

[8] “Ambisexual.” Merriam-Webster.com. Accessed: Feb. 4, 2025. [Online.] Available: https://www.merriam-webster.com/dictionary/ambisexual.

[9] C. Freedman, *Conversations with Ursula K. Le Guin*. Jackson, MS, USA: Univ. Press of MS, 2008, p. 99.



Thank You

We would especially like to thank **The Kalhert Foundation** for their support of our students and specifically this journal. The Kalhert Foundation is interested in Education in general and specifically Education in the STEM fields.

Journal of Research in Progress

HOWARD COMMUNITY COLLEGE