Bridging the Gap: Developing and Studying the Effects of Educational Resources to Increase Environmental Awareness, Science Proficiency, and Sustainability in Alabama's Schools and Communities

By:

Carly Cummings

A dissertation submitted to the Graduate Faculty
Auburn University
In partial fulfillment of the
Requirements for the Degree of
Doctorate in Philosophy

Auburn, Alabama
August 3, 2024

Keywords: Sustainability, Education, Equity, Outreach

Approved By:

Dr. Maria Soledad Peresin, Chair, Assistant Professor of Forest Biomaterials, Auburn University
Dr. Karen McNeal, Professor in the Department of Geosciences, Auburn University
Dr. Becky Barlow, Associate Dean for Extension & Assistant Director for Agriculture, Forestry and Natural Resource Extension Programs, Auburn University
Dr. Eve Brantley, Professor and Extension Specialist, Auburn University
Dr. Michael Curry, Professor of Nanoengineering, North Carolina Agricultural and Technical State University
Dr. Paul C. Bartley, Assistant Professor in the Department of Horticulture, Auburn University

Abstract

This study addresses the critical need for sustainable practices amidst rising global temperatures and increasing environmental risks. Recognizing human behavior as a primary contributor to these challenges, it emphasizes the necessity of harmonizing economic, social, and environmental objectives. The United States, particularly the Southeast, faces significant environmental challenges compounded by historical educational, economic, racial, and geographical inequities. Alabama confronts unique educational hurdles while also holding potential for developing sustainable solutions. This research aims to explore the inequities in science education within Alabama and proposes solutions to enhance science proficiency and environmental awareness through equitable and relevant resources.

This study is structured into four key investigations. The first study assesses the science proficiency gap by analyzing demographics, educational achievement, funding, and geographic locations across Alabama's public-school districts. The second study develops, implements, and assesses a classroom lesson on sustainable bio-based materials, focusing on active problem-based learning related to forest products and water remediation. The third study organizes and evaluates a community event to boost public understanding and practice of sustainability. The fourth study provides a qualitative assessment of a mentorship program for minority students, examining its impact on science proficiency and interest. Overall, this research aims to propel Alabama towards sustainability by addressing historical educational inequities and developing impactful, relevant learning materials. The findings have the potential to inspire further research and educational interventions across the United States and the Southeast, contributing to a

broader movement towards equitable and effective science education and sustainable development.

Acknowledgements

First and foremost, I would like to express my deepest gratitude to my advisor, Dr. Maria Soledad Peresin. Her constant belief in me and her mentorship over the years have been invaluable. Dr. Peresin's guidance and encouragement have shaped this dissertation, my academic journey, and my aspirations for the future in ways I could not have imagined. I would also like to thank Dr.Adriana Restrepo Osorio, her constant positivity and loving support have been pivotal in my academic and professorial growth.

I am also profoundly grateful to my family for their unconditional support and belief in me. Their love and encouragement have been my anchor throughout this journey. Thank you, Mom, Dad, Joe, Meghan, Tommy, Kristin, and Christian, for always being there for me and for your endless encouragement. I would also like to extend my heartfelt thanks to the Young Professionals in Training for welcoming me into their program. Their enthusiasm and dedication have been a source of inspiration, and I am grateful for the opportunity to have worked alongside such passionate individuals. Additionally, thank you to all the volunteers for Rallying for Sustainable Communities; especially Sebastian, Monet, James, Sydney and Yufei. Moreover, thank you to the Miller Writing Center, Dr. Christopher Basgier, Dr. Layli Miron and Dr. Katharine Brown, for your unwavering support and for providing me with countless experiences to work with others throughout this journey whom I have learned and grown from.

Lastly, I would like to thank Coach Ryan Wochomurka, Bryan "PK" Karkoska, and the entire Auburn Swim and Dive team. Being part of such a dedicated and resilient team has taught me invaluable lessons that extend far beyond the pool. To the many others who have been a part of this journey and have stood by my side, thank you all.

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List of Abbreviations

5-E's	Engage, Explore, Explain, Elaborate, and Evaluate.
ArcGIS	Geographic information system (GIS) software suite developed by Esri, the Environmental Systems Research Institute
AU	Auburn University
BBSD	Black Belt School Districts
CCR	College Career Readiness
CDC	United States Centers for Disease Control
d	Cohen's D Value
DDS	Doctor of Dental Surgery
EJI	Environmental Justice Index
EPA	Environmental Protection Agency
ESD	Education for Sustainable Development
etc.	et cetera
GHG	Green House Gases
GR	Graduation Rate
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JD	Juris Doctor
K-12	Kindergarten- 12th grade
M	Mean
MA	Master of Arts
MANOVA	Multivariate Analysis of Variance
MBA	Master of Business Administration
MD	Doctor of Medicine
MS	Master of Science
NAEP	The National Center for Educational Progress
NBBSD	Non-Black Belt School Districts

NEPA	National Environmental Policy ACT
NOAA	National Oceanic and Atmospheric Administration
p	Significance Value
PBL	Problem Based Learning
PhD	Doctor of Philosophy
PPE	Per public Expenditure
r	Correlation Coefficient
SD	Standard Deviation
SDG	Sustainable Development Goals
SP	Science Proficiency
STEM	Science, technology, engineering, and mathematics
t	Sample Size
TBL	Tased Based Learning
U.N	United Nations
U.S	United States
UNDESD	The United Nations Decade of Education for Sustainable Development
YPiT	Young Professionals In Training

Introduction and Background:

1.1 Sustainability and Climate Change

Sustainability is the practice of establishing harmony between human behavior and the consumption of our natural environment to maintain healthy environmental conditions to support future generations (Lynch & Sachs, 2021; Taghvaee et al., 2022). To achieve sustainability multiple principles and perspectives must be addressed, including economic, social, and environmental conditions (Figure 1) (Taghvaee et al., 2022).

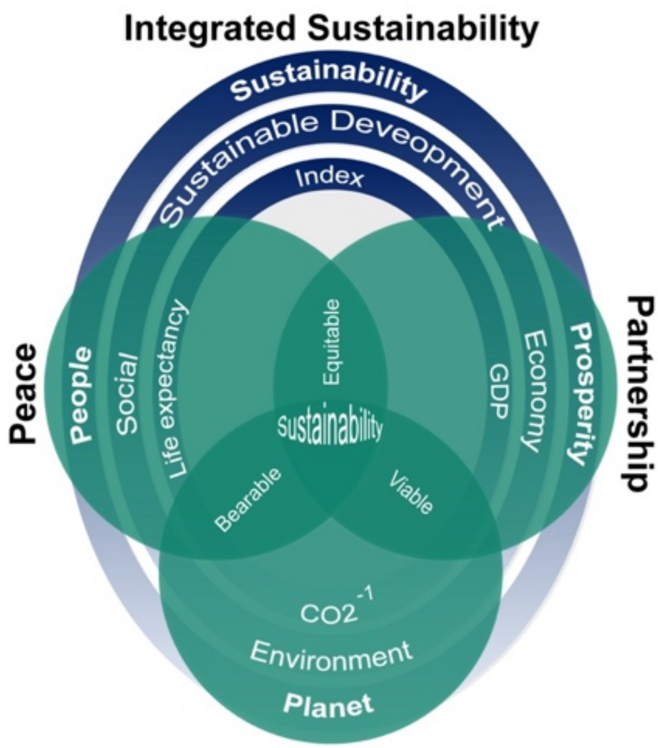

Figure 0-1: The Perspectives of Sustainability (Taghvaee et al., 2022)

The call for sustainability has never been greater due to increasing global temperatures and resources consumption. In 2022 the United States (U.S) National Oceanic and Atmospheric

Administration (NOAA) reported that Earth's temperature has risen an average of 0.14°F (0.08° Celsius) each decade since 1880 (National Centers for Environmental Information, 2023b).

Moreover, the ten warmest years in the last 143 years have all occurred since 2010, with the nine warmest occurring between 2014-2022 (National Centers for Environmental Information, 2023a; Vose et al., 2021). According to Lindsey (2023), the increase of global temperatures is directly related to human greenhouse gas emissions. Greenhouse gases (GHG) are elements such as water vapor, nitrous oxide, and carbon dioxide, that exist within Earth's atmosphere and absorb inferred radiation, thus inhibiting heat from escaping back into space (IPCC, 2019); this is known as the greenhouse effect.

The greenhouse effect is a natural process that is necessary to sustain life on earth. Prior to human contribution, GHGs were emitted through natural processes such as respiration, volcanic activity, and evaporation. However, according to the U.S Environmental Protection Agency (EPA) the rate of greenhouse gas emissions changed dramatically following the Industrial Revolution in the mid 1700s when humans began extracting fossil fuels to produce energy (US EPA, 2021). Fossil fuels are non-renewable hydrocarbon deposits that are made from the deposition and burial of prehistoric plant and animal remains (Smithsonian, n.d.). It can take millions of years for fossil fuels to form, making them a limited natural resource and an unsustainable choice for energy production. Furthermore, when fossil fuels are consumed, they emit anthropogenic, or human derived, carbon dioxide which can be identified through its unique isotope (Lindsey, 2022; US EPA, 2021).

Overall, the increase of carbon dioxide from 1800-2022 is 70% larger and 100-200 times faster than the changes seen after the last ice age (between 17,500 and 11,500 years ago); further highlighting the impact and contribution of human behavior towards climate change and environmental degradation (Lindsey, 2022). NOAA's assessment of annual global surface temperatures and atmospheric carbon dioxide from 1850-2023 can be seen in Figure 2.

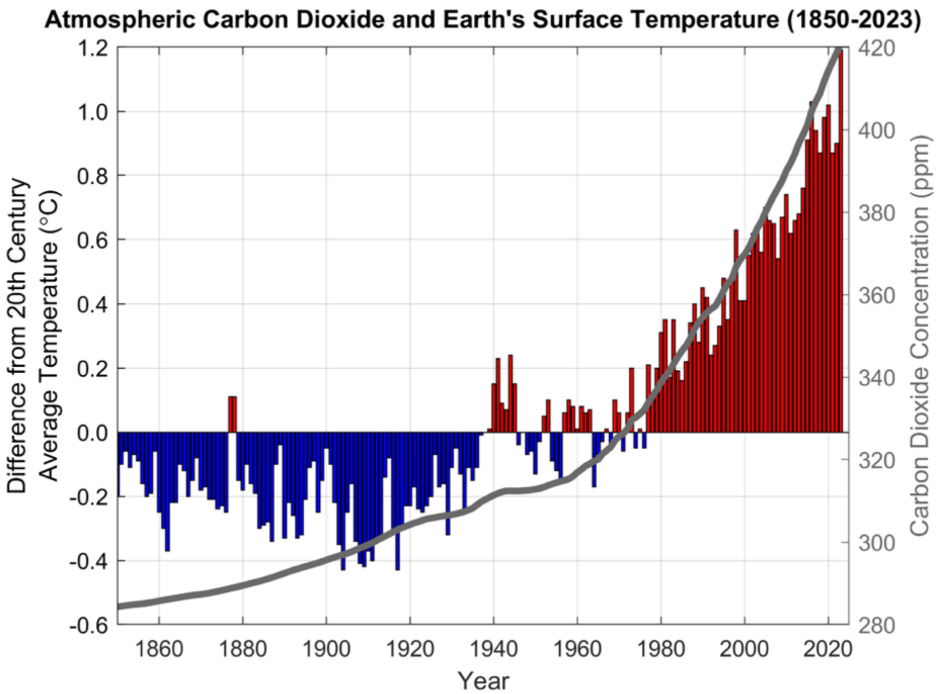

Figure 0-2: Yearly global surface temperature and atmospheric carbon dioxide trends from 1850-2022 (Lindsey, 2023).

Red bars represent warmer than average, blue bars represent colder than average, and atmospheric carbon dioxide amounts is represented by the gray line. from IAC, 1959-2019 from NOAA ESRL. Original graph by Dr. Howard Diamond (NOAA ARL) and adapted by NOAA Climate.gov.

The increase of global annual temperature has developed environmental challenges across the globe. Higher temperatures have created increased rates in evaporation, and thus, precipitation and desertification (Adler et al., 2017). Additionally, increased global temperatures have increased the frequency and intensity of extreme weather events and natural disasters such as drought, hurricanes, flooding, and wildfires (Pörtner et al., 2022). The change in climate and increased rate of natural disasters has directly impacted individuals' quality of life through the increase of food and water insecurity, land and property damage, mortality rates and high-risk labor (Pörtner et al., 2022). Moreover, without the effective policy to mitigate climate change and environmental degradation, these risks are predicted to increase globally and within the United States, as seen in Figure 3 (Hsiang et al., 2017). Moreover, these challenges are predicted to substantially impact the Southern region of the United States (Hsiang et al., 2017), as well as individuals and communities who are challenged socio-economically (Sachs et al., 2022).

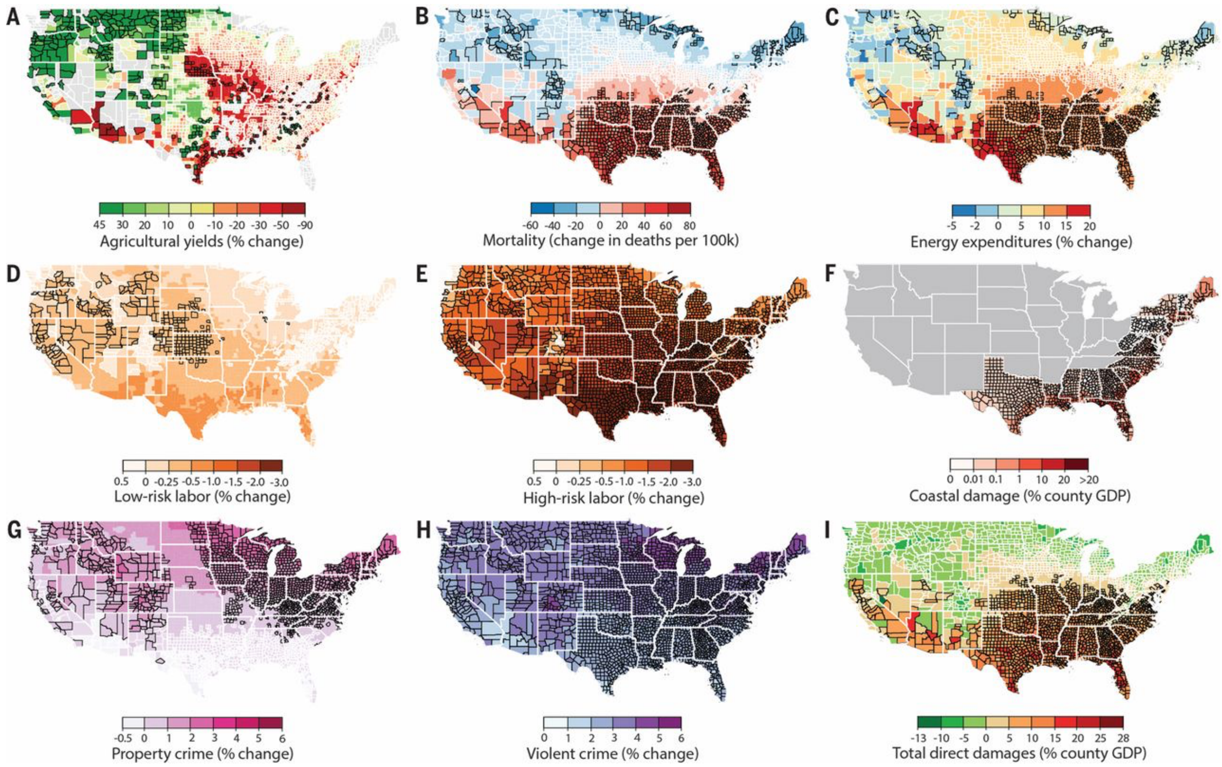

Figure 0-3: Projected damages during the period 2080 to 2099 (Hsiang et al., 2017):
"County-level median values for average projected damages during the period 2080 to 2099. Impacts are changes relative to counterfactual "no additional climate change" trajectories. (A) Percent change in yields, area-weighted average for maize, wheat, soybeans, and cotton. (B) Change in all-cause mortality rates, across all age groups. (C) Change in electricity demand. (D) Change in labor supply of full-time-equivalent workers for low-risk jobs where workers are minimally exposed to outdoor temperature. (E) Same as (D), except for high-risk jobs where workers are heavily exposed to outdoor temperatures. (F) Change in damages from coastal storms. (G) Change in property-crime rates. (H) Change in violent-crime rates. (I) Median total direct economic damage across all sectors [(A) to (H)]." Image developed, published and copyright held by Hsiang et al. (2017).

As mentioned previously, increased global temperatures are caused by the overconsumption and use of fossil fuels, however, fossil fuels are not the only natural resources humans are consuming at alarming and unsustainable rates. In 2019 the European Union's

European Environment Agency evaluated the global consumption of natural resources, including fossil fuels, biomass (renewable organic material), metals and non-metallic minerals (European Environment Agency, 2019). The evaluation highlighted the increasing and unsustainable rate at which natural resources are being consumed worldwide, as seen in Figure 4.

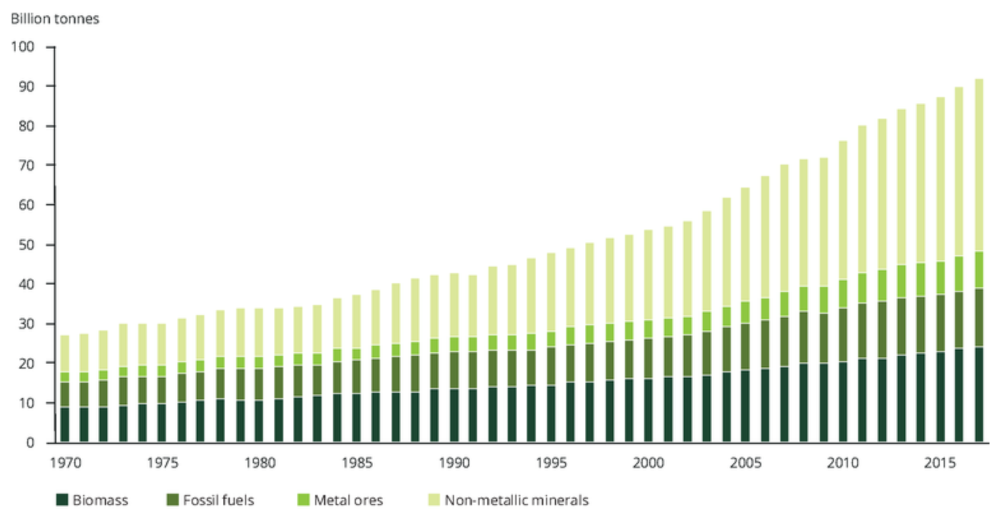

Figure 0-4: Trends in global domestic extraction of materials, 1970 – 2017
(European Environment Agency, 2019) Copyright holder: European Environment Agency (https://www.eea.europa.eu/legal/copyright).

Furthermore, humanity is consuming past global biocapacity, meaning resources are being extracted faster than the Earth can produce or provide (Oberle et al., 2019). A study conducted by York University and the Global Footprint Network (2023) assessed global resource consumption through the evaluation of land use, carbon production, fishing, and forestry. According to this study, the world had been consuming past the Earth’s resource reserve since 1971, and since 2005 the world has been consuming as many ecological resources as if they lived on more than 1.5 “Earths”.

It is also important to note that resource consumption is not equal, high-income nations are responsible for 74% of global excess material use (Hickel et al., 2022). According to Hickel et al. (2022) the highest consuming nations are the U.S (27%), the European Union (25%) and

China (18%). Low-income and middle-income countries (as defined by Hickel et al. (2022) as Latin America, the Caribbean, Africa, the Middle East, and Asia) are only responsible for 8% of global material use. The global distribution of resource consumption by national income is represented in Figure 5. As global population increases, it is critical to develop solutions to decrease the rate of consumption and educate the public on their ecological footprint. Moreover, it is essential to evaluate the equity of ecological consumption and how the unsustainable practices performed by high-income nations can impact lower-income countries and populations.

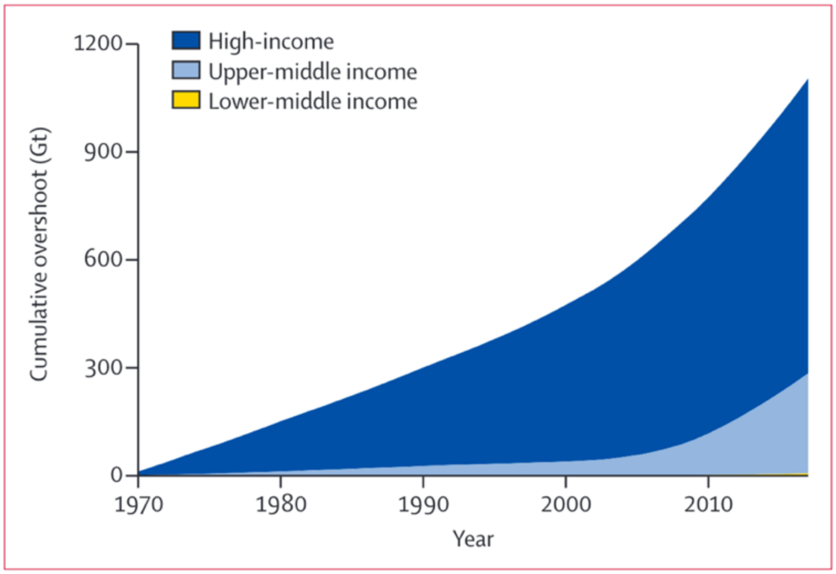

Figure 0-5: Years in Which Natural Resource Use Has Exceeded Earth's Resource Availability, Broken Down by Country's Income (Hickel et al., 2022).

1.2 Environmental Injustice

Environmental inequities can be seen beyond the assessment of global resource consumption. According to the International Panel on Climate Change's (IPCC) 2022 report, environmental risks induced by climate change disproportionately affect marginalized groups (Birkmann et al., 2022). The report also states, with high confidence, that the highest damages and losses will be concentrated in the poorest and most vulnerable populations. The IPCC believes that the current inequities that exist within economics, social constructs, policy, and education are what heightens these risks. Furthermore, if these inequities are not addressed these risks will further intensify overtime.

Environmental inequities can be seen across economic, gender, racial, and cultural groups. In 2016, Bell reported that women have a higher vulnerability to environmental risks due to societal inequities including wage gaps and professional/career expectations. Bell's report states that the environmental inequities that women face make them more likely to experience environmental burdens which impact their health and are less likely than men to have control over environmental decisions. Alongside gender inequities, environmental injustice can be seen within racial groups as well. In 2019, Tessum et al. reported that in the United States, Caucasian groups were exposed to around 17% less pollution than they created, while Black populations were exposed to 56% more pollution than they created and Hispanic populations were exposed to 63% more. Furthermore, a study conducted in England in 2015 found comparable results, stating that the highest level of air pollutants was seen in communities in which more than 20% of the population are non-white (Fecht et al., 2015).

As mentioned previously, lower-income communities are expected to experience higher environmental risks over time (Birkmann et al., 2022). Studies conducted in the United States found that communities struggling socio-economically have experienced greater impacts from storms, floodings, extreme heat, and infectious diseases (Gutierrez & LePrevost, 2016; Flores et al., 2021;Hilmers et al., 2012). An international study conducted by Hilmers et al. (2012) found that lower-income communities have a higher likelihood of experiencing food desserts, and lower accessibility to affordable nutrition. Moreover, economically disadvantaged, indigenous and rural populations are least likely to have access to clean water (Mason & Sarwar, 2017).

These global inequities have inspired a call for environmental justice. According to the United States Department of Health and Human Services, environmental justice is the call for fair treatment and involvement of all people to promote environmental laws, regulations and policies that seek to establish equal protection from environmental and health hazards, and equal access to the decision-making process to live, learn, and work in a healthy environment (U.S. Centers for Disease Control, 2023).

To help facilitate the implantation of equitable environmental policy, organizations such as the United States Department of Health and Human Services have developed a measurable index to locate areas and populations of concern. The U.S Environmental Justice Index (EJI) uses data from the U.S. Census Bureau, the U.S. Environmental Protection Agency, the U.S. Mine Safety and Health Administration, and the U.S. Centers for Disease Control and Prevention to rank environmental injustice on health for every census subdivision variable (U.S. Centers for Disease Control, 2023). The U.S. Centers for Disease Control (CDC) explains that the EJI ranks environmental injustice through environmental, social, and health factors. Examples of these factors include access to health care, economic stability, quality education, extreme weather, food and water security, pollution exposure and housing. Results of the most recent EJI assessment highlight the Southeastern region of the United States as an area of great concern, featuring the high densities of counties experiencing environmental injustice (Figure 6).

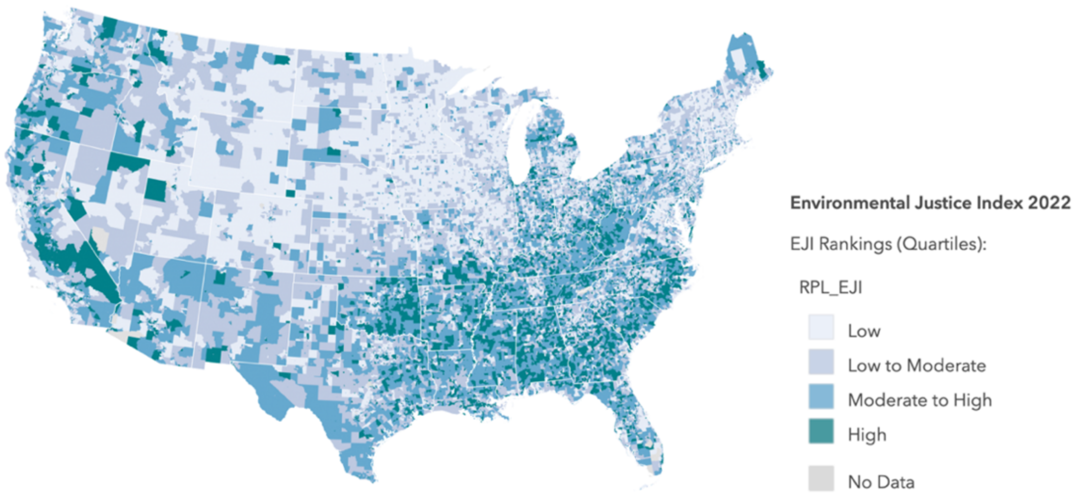

Figure 0-6: United States Environmental Justice Index (U.S. Centers for Disease Control, 2023)

1.3 United Nations Sustainable Development Goals

To combat climate change, environmental injustice and to mitigate environmental challenges globally, the United Nations (U.N) has committed to sustainability and environmental research. In 1988 the U.N established the IPCC, an annual collaborative report from researchers across the globe that assesses data related to climate change to help policy makers develop legislation that promotes sustainability. On January 1st, 2015, after decades of climate assessment, the U.N established 17 Sustainable Development Goals (SDG) to be obtained by 2030 (Sachs et al., 2022). These 17 goals were unanimously adopted by 193 member countries of the U.N and cover a range of initiatives to protect the planet, ensure equitability and inclusivity, all while promoting economic development, peace, and prosperity. To evaluate progress, U.N countries are required to report data on each variable and are encouraged to promote policy and regulation to ensure these goals are met. The 17 SDG set by the U.N can be seen in Figure 7.

Figure 0-7 : United Nations Sustainable Development Goals
A list of the 17 goals set by the United Nations in 2015 to progress towards Sustainability. These goals are expected to be met by 2030. Images and data owned and developed by the United Nations (Martin, 2015).

Furthermore, in 2016 the U. N's initiatives towards sustainability became legally binding with the signing of the Paris Agreement; 196 countries adopted this agreement (*The Paris Agreement | United Nations Climate Change*, n.d.). The goal of this agreement was to limit the increasing average global temperatures to below 2^{o}C (above pre-industrial levels) and have countries pledge their commitment to reduce their own GHG emissions, thus implementing sustainable practices. To this end, the U.N seeks to reduce carbon emissions by 45% by 2030 and reach net zero carbon by 2050.

1.3.1 The Significance of Education for Sustainable Development

The fourth SDG emphasizes the role education plays in achieving sustainability, inclusivity, justice, and economic prosperity within environmental limits (Martin, n.d.). The U.N acknowledges quality education as an essential tool to address and achieve the remaining goals established (United Nations Educational, Scientific and Cultural Organization, 2015). The subgoals included withing the fourth SDG stress the need for equitable quality education for all children and adults regardless of race, culture, gender, and socio-economic background. These include the development of quality facilities, a sustainable supply of qualified educators, scholarships and meaningful curriculum that will prepare students for professional careers and post-secondary education. Moreover, goal 4.7 seeks to ensure that all learners acquire the knowledge and skills needed to promote sustainable development by teaching sustainable lifestyles, addressing human rights, gender equality, and promoting a culture of peace, global citizenship and diversity and the overall awareness of human contribution to the environment and how culture contributes to sustainable development.

To mitigate environmental challenges and promote sustainable practices, addressing public perception, values and their understanding is critical, especially in younger generations. The United Nations Decade of Education for Sustainable Development (UNDESD) was developed by the United Nations Educational, Scientific and Cultural Organization in 2005-2014 to address this goal; this initiative sought to mobilize the educational resources of the world to help create a more sustainable future (United Nations Educational, Scientific and Cultural Organization, 2015). The main target of the UNDESD was to integrate sustainable development principals into learning processes, encouraging nations to enhance standards and curriculum to promote environmentally conscious behavior in younger generations (Liimatainen, 2013). The framework of the UNDESD recommends integrating the multiple dimensions of sustainability including economic, environmental, social, and cultural issues. Furthermore, the UNDESD recommends that lessons be taught through pluralistic (promoting critical thinking and discussion for students to gather their own opinions on subjects) and holistic learning (addressing the multiple perspectives of sustainability: i.e. social, environmental, and economic variables), critical thinking, problem-solving and locally relevant information.

Several nations participated in UNDESD by implementing sustainability principles into their education systems curricula and have since been evaluated by researchers. In 2015 Pauw et al. evaluated data from 2413 students in grades 6, 9, and 12 from 51 schools across Sweden to assess the effectiveness of UNDESD's framework for Education for Sustainable Development (ESD) (Pauw et al., 2015). Although Pauw found that UNDESD's framework can indeed impact student outcomes in terms of their sustainability consciousness, there is a need to implement more effective pedagogical approaches, specifically connecting the ideas of holistic and pluralism framework. Pauw et al. (2015) also states that there is a need to consider other concepts within sustainability outside of consciousness, such as time, risk perception, self-determination, and self-efficacy. A study produced by Kopnina (2020) also criticizes the framework presented by UNDESD, stating that it is centralized around economic sustainability (thus not holistic) and neglects cultural perspectives of teaching and education. To complement the findings of Pauw et al. (2015) and Kopinia (2020), research presented by O'Flaherty & Liddy (2018) and Kioupi & Voulvoulis (2019) highlight the need to propose appropriate and effective educational framework, and to develop a common vision for sustainability to better implement holistic and pluralistic principals.

To propose a solution to the conflicts of UNDESD pedagogy, Sinakou et al. (2019) suggests an enhancement to holistic and pluralistic frameworks through the addition of action-oriented learning. The framework of action-oriented learning presented by Sinakou et al. (2019) centers around students leading and developing solutions to environmental issues by identifying the cause, all while participating in peer discussion. Within this framework students will address pluralism through critical thinking, discussion and the formulation of individual opinions and solutions. Holism is also applied in this approach by highlighting the interconnectedness of sustainability through their proposed solutions and understanding of the challenge at hand. Although the concept of Holism-Pluralism-Action-orientation ESD framework seems promising, this study was solely a review of educational framework and did not apply this approach to a classroom setting; to this end more research is needed to evaluate the effectiveness and practicality of this proposed framework.

In summary, previous research suggests the need to further research and develop ways to enhance education on sustainability. Moreover, previous work suggests that for educational efforts to be effective they should incorporate effective pedagogy, contain measurable objectives, and foster a clear definition of sustainability.

1.4 United States Progress Toward Sustainability

Despite legal obligations, several nations are failing to develop progress towards sustainability, including the United States (U.S). The U.S has been committed to the SDG set by the U.N (Sachs et al., 2022), and is currently committed to the Paris Agreement as well (Blinken, 2021). According to the 2022 Sustainable Development Report, the U.S is currently ranked 39th in the U. N's progress towards sustainability rankings and has not achieved any of the 17 goals (Sachs et al., 2022). The lack of progress produced by the United States is of grave concern considering its global environmental impact.

Currently, the United States is one of the largest producers of GHG emissions per capita (Kuramochi et al., 2019) and consumers of natural resources (Hickel et al., 2022). With the United States hosting one of the largest environmental footprints in the world, their failure to progress towards sustainability is of concern. Therefore, it is essential for the US to evaluate its behavior on a domestic level; allowing the country to pinpoint geographic areas of concern which will allow for the development of effective resources and assistance to aid these regions in sustainable development.

1.4.1 Southeastern Sustainability and Vulnerability to Climate Change

In 2021 the United States released a report on its progress towards sustainability with a progress evaluation of all 50 states (Lynch & Sachs, 2021). Southeastern and rural states on average rank in the lower percentile of sustainable progress, with the last five states being Alabama, Oklahoma, Arkansas, Louisiana, West Virginia, and Mississippi, respectively. Consequently, these regions also host the highest risks of projected damage derived from climate change (Hsiang et al., 2017). According to Carter et al. (2014) the Southeast is expected to experience heightened rates of sea level rise, habitat loss, increasing temperatures and severe weather. The reason the Southeast is vulnerable to climate change-related events is due to its latitude, topography, and proximity to oceans (Carter et al., 2014). As mentioned previously, these projected damages are predicted to impact these regions geographically, socially, and economically.

1.4.2 Environmental Injustice in the Southeastern U.S

When evaluating the Southeast’s progress towards sustainability and evaluation of climate change risks, it is important to highlight the social and environmental inequities that occur in this region. Many of the SDG developed by the U.N are rooted in addressing racial, gender, cultural and economic injustices (Martin, 2015); to maintain prosperity over time it is vital to create equitable environments and resources to address historical inequities and provide opportunities for the entirety of society to prosper over time. As indicated earlier, there are currently many gender, racial, geographical, and cultural inequities across the globe that hinder the progress of sustainability and place certain groups at higher environmental and economic risk. According to the 2021 U.S Sustainable Development progress report, the poor performance of the US states reflects, among other factors, the enormous inequality in American society which is clearly divided by class, race, gender, and geography (Lynch & Sachs, 2021).

Devlin et al. (2014) states, that in the Southeast U.S, individuals who reside in rural or geographically isolated areas are more likely to experience heightened effects of changing climate, especially compared to those residing in other areas. This is of greater concern considering the prevalence of rural residents (40.8% of total population) in the Southeast (Census Bureau, 2022). It is also important to note economic inequities in the South, since 2007, rural median income has averaged 25 percent below the urban median (United States Department of Agriculture, 2017). The economic disadvantage the Southeast faces places individuals at risk without the financial freedom to address these challenges. Furthermore, this economic disadvantage is predicted to be further stressed over time with Southeastern industry being reliant on a well-balanced environment to maintain agricultural, forestry and fishing practices. Without economic stability the Southeast will continue to face challenges in mitigating environmental risks and implementing sustainable practices.

Along with economic inequities the Southeast faces racial and health inequities strengthened by climate change. Historically, rural minorities have faced a greater disadvantage for health status and health care (Molla et al., 2004; Olshansky et al., 2012). According to Singh and Siahpush (2014), rural residents in the U.S. have reduced longevity as compared to urban communities. Additionally, Singh and Siahpush determined that poor rural African Americans averaged a 67.7-year life expectancy, which is substantially less than minorities of equal socio-economic status in urban areas. A synthesis by Gutierrez and LePrevost (2016) overviews additional climate change induced health risks of vulnerable populations in the Southeast, which include greater likelihoods of asthma, cancer, heart complications, development, neurological disorders, vector-borne diseases, waterborne diseases, and mortality (Figure 8).

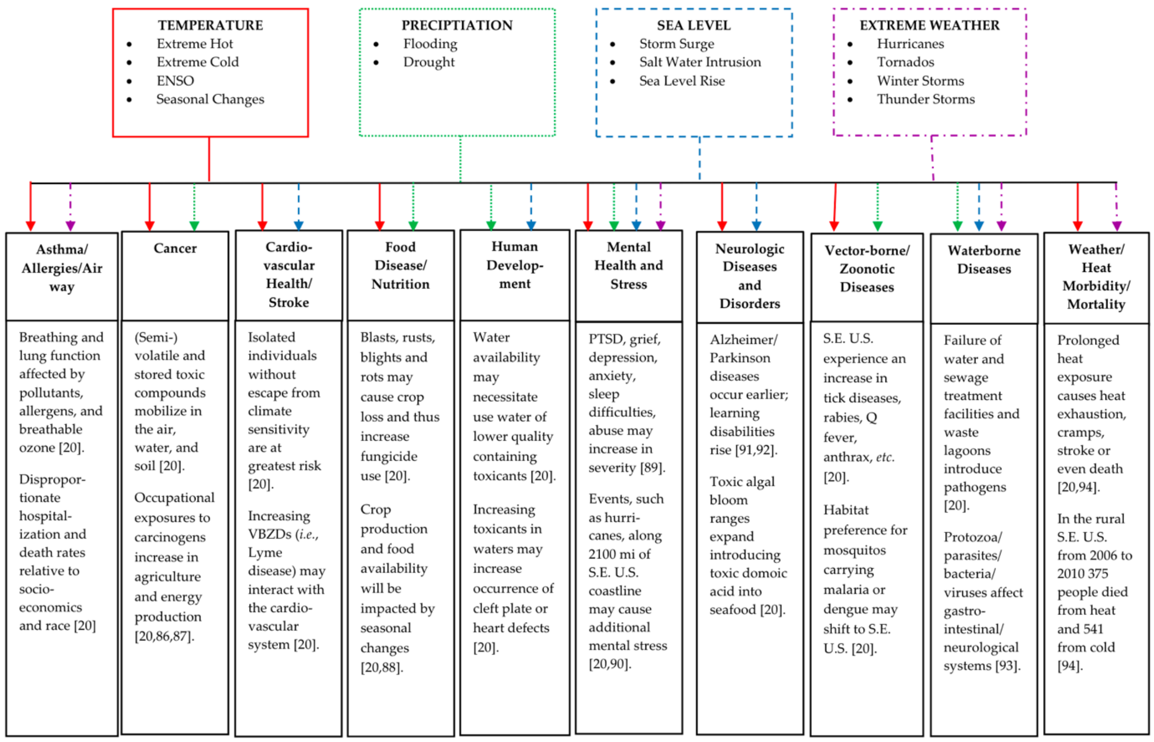

Figure 0-8: Health effects of climate change in vulnerable populations in the Southeastern U.S. connected to temperature, precipitation, sea level change, and extreme weather events. Graph developed and copyright held by Gutierrez & LePrevost (2016).

While education is fundamental to promote sustainability and address environmental injustices, the Southeast faces many educational challenges, as shared in an evaluation of kindergarten- 12th grade (K-12) educational standings produced by Robson et al. (2019). In this report, Robson et al. shares that more than one third of all K-12 students reside in the Southeast, as well as 56% of all Black students. Currently, the Southeast averages the lowest educational achievement scores which are influenced by inadequate funding, curriculum standards and social inequities. Student funding (per-pupil spending) and teacher salaries in the Southeast are below national averages. Moreover, school district underfunding is greatest in rural minority communities. The underfunding of schools directly impacts educational achievement through limited access to educational resources needed to promote learning.

Robson et al. (2019) also addresses that systemic and historical implications contribute to the lack of progress within Southeastern education systems. Prior to the Freedman's Bureau Act in 1865 (which was passed following the Civil War and emancipation of slaves) Black children did not have access to formal education in America (*U.S. Senate: Freedmen's Bureau Acts of 1865 and 1866*, n.d.). In the same year, to combat equitable resources and to maintain systemic racism following the Civil War, Southeastern states enacted the Jim Crow Laws which legally segregated communities and resources including schools and school funding (Wilson, n.d.). It wasn't until 1954 that segregation became illegal, following Brown vs. Board of Education (Ramsey, 2019). However, although desegregation was enforced, communities across the South experienced an epidemic known as "White Flight", where white families migrated out of newly diverse areas to maintain predominantly white communities and schools (Mann & Rogers, 2021). Additionally, many white communities established racially and economically exclusive private schools to further maintain segregation. The impact of racial segregation and "White Flight" can still be seen today; Mann and Rodgers (2021) state that segregation patterns have continued over time, and in some areas have worsened.

1.4.3 The Southeastern Black Belt Region

One of the areas of great concern within the Southeast regarding environmental inequities is the Black Belt. The Black Belt region, named for its dark rich soil, is a historic geographic area within the Southeast which formally hosted large concentrations of slave plantations, sharecroppers, and the Civil Rights Movement (Winemiller, 2023). This extensive region stretches over ten states within the Southeast and can be seen in Figure 9 (Ambinakudige et al., 2012). Currently, the Black Belt still hosts the largest concentrations of Black and African American populations, rural industries, as well as economic, social and education inequalities within the Southeast (Ambinakudige et al., 2012; Holifield, 2023; Katsinas, Noel, et al., 2023; Katsinas, Till, et al., 2023; Mann & Rogers, 2021; Prior & Wong, 2022) To this end, as stakeholders seek to implement sustainable practices and address environmental inequities it is vital to consider the Black Belt region and provide resources to better support members of these communities.

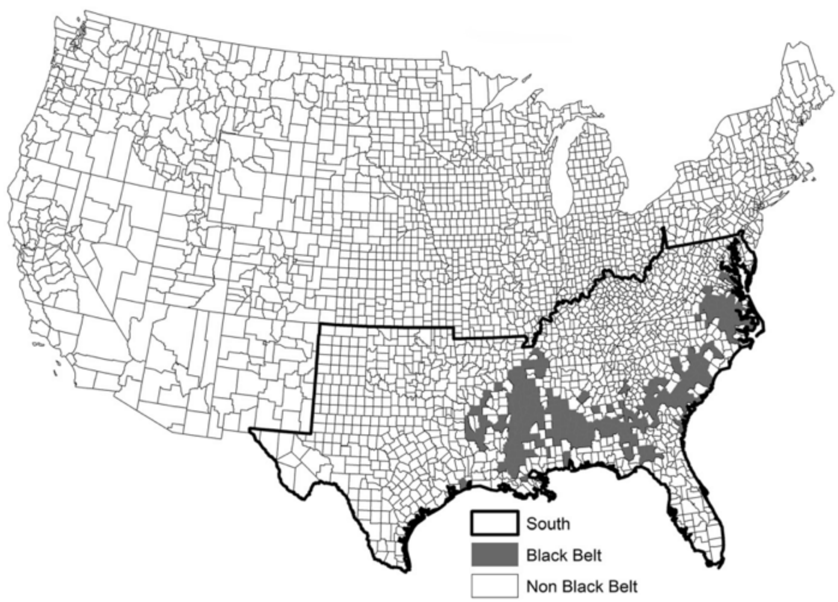

Figure 0-9: Map of the Black Belt Region (Ambinakudige et al., 2012)

1.5 Alabama's Progress Toward Sustainability

Within the southeastern United States, Alabama, a state with significant stake in environmental resources and sustainable practice, confronts its own challenges. Alabama currently ranks 45th in the country regarding their progress toward sustainability (Lynch & Sachs, 2021). Alabama is a state of concern within the United States considering the role natural resources and climate conditions play towards their economic stability. Alabama is 70% woodland (Randle, 2020), and hosts over 132,000 miles of rivers and streams (Alabama River Alliance, 2020; Geological Survey of Alabama, n.d.), over 50 miles of coastline, and is considered one of the most biodiverse regions in the country (Duncan, 2013). According to the United Nations, Alabama's largest challenges towards sustainable progress include economic, racial, gender equality, as well as education, health, and the development of sustainable communities (Lynch & Sachs, 2021). Alabama's SDG dashboard and trends can be seen in Figure 10 below.

Figure 0-10: Alabama's SDG dashboard and trends (Lynch & Sachs, 2021)

Alabama's highest grossing industries are dependent on natural resource availability and stable environmental conditions; examples of these industries include agriculture, metal and advanced materials, chemicals, bioscience, and the forest products industry (Alabama Department of Commerce, 2022). The forest products industry, in particular, plays a significant role in Alabama's progress toward sustainability, as it is a critical natural resource. This review will focus on the forest industry's role in Alabama's progress toward the SDGs and identify areas where it can enhance this progress further.

According to the Alabama Department of Commerce (2022), the forest products industry's total value of manufactured products exceeds $12.5 billion annually and is the second largest timberland base in the United States. The forest industry in Alabama has a total job output of 123,477 which supplies 157% more forest-related jobs compared to average U.S. Forest regions (Alabama Forestry Commission, 2020). To maintain economic prosperity, it is essential for Alabama to prioritize the conservation, health, and growth of its forests. This not only ensures environmental stability but also secures the longevity of resources that generate revenue over time.

The 12th SDG focuses on ensuring sustainable consumption and production patterns; Alabama is currently moderately improving in this area (Lynch & Sachs, 2021) (Figure 11) which is exemplified within their forest products industry. Currently the growth of softwood and hardwoods consistently outpaces their removal rates; meaning Alabama is growing more trees than they are extracting (Alabama Department of Commerce, 2022; Alabama Forestry Commision, 2020). According to the Alabama Forestry Commission (2020), forests are essential for environmental stability; forests sequestered carbon dioxide in the atmosphere and produce oxygen, they also help produce clean drinking water, cycle nutrients, and are habitats for wildlife. To this end, the balance between natural resource conservation and consumption within the forest industry is essential for long term productivity and can help the state reach the 15th SDG: protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (Lynch & Sachs, 2021). Currently Alabama is moderately improving towards the 15th SDG, however significant challenges remain. Alabama's progress toward SDG 12 and 15 can be seen in Figure 11.

Figure 0-11: Alabama's progress toward SDG 12 and 15 (Lynch & Sachs, 2021)

According to the Alabama Forestry Commission (2020) the current products produced by Alabama include pulp, paper, paperboard production, lumber, panel production. Although currently successful and lucrative, Alabama's forest products industry has the potential to further leverage itself by producing additional products that can be used to increase sustainability and mitigate environmental challenges enhanced by climate change.

To begin, developing plant-based packaging materials through forest products can replace non-biodegradable fossil-fuel-based products (Liu et al., 2021). Currently plastic materials and packaging are primarily developed through fossil fuels, which can take up to 500 years to begin to degrade. According to the United Nations Environment Programme (2021), humans produce over 400 million tonnes of plastic waste every year. Moreover, fossil-fuel based plastics leech harmful chemicals and toxins which not only impact the health of ecosystems (United Nations, 2021), but can also disrupt human health and functionality (Harvard Health, 2019). Packing materials that are composed of plant-based materials pose many solutions to plastic-based products. The plant materials that are used to develop these products are renewable and more available than fossil-fuels (Seddiqi et al., 2021). Bio-based packing has also proven to be just as effective to protect materials such as food (Vilarinho et al., 2018) and can biodegrade in a timely manner (Kale et al., 2007). Therefore, producing bio-based packaging materials through forest biomaterials will not be an economic asset for Alabama, can also mitigate environmental challenges.

Along with packaging materials, forest biomaterial can be used to address environmental challenges relating to energy. Research has shown that biomaterials derived from trees can be used to create biofuels, reducing the demand and reliance of fossil fuels (United States Department of Agriculture, n.d.). According to the United States Department of Energy, biofuels burn cleaner than gasoline (emit less carbon dioxide), resulting in fewer greenhouse gas emissions, and are fully biodegradable (United States Department of Energy, n.d.). In 2022 the International Energy Agency shared the growing global demand for biofuels, estimating demand to increase more than 20% between 2020 and 2027 (International Energy Agency (IEA), 2022). While biofuels are not the perfect solution to developing clean energy, they increase sustainability and decrease global ecological footprints. To this end, forest produced biofuels present another economic and ecological opportunity for Alabama.

Another product of interest is bio-based water treatment materials. Plant-based materials have large adsorption and absorption potential (Voisin et al., 2017), allowing them to capture a wide range of contaminants. Biomaterials can remove contaminants in water by adsorption or absorbing harmful substances, regardless of oxidation state. Bio-based filtration can even be used to help treat toxic waters created by emerging contaminants (i.e. microplastics (Wang et al., 2023), oil spills (Hammouda et al., 2021) and heavy metals (Moharana et al., 2023)) as well as nitrates and phosphates which derive from fertilizers and cause eutrophication in aquatic systems (Gizaw et al., 2021).

Eutrophication in particular has become a pressing issue in Southeastern states due to the prevalence of fertilizers, and agricultural waste and increased runoff induced by rising global temperatures (Gurung et al., 2013; Mirhosseini & Srivastava, 2016). Eutrophication occurs when nitrates and phosphates accumulate in large concentrations in aquatic ecosystems, this can trigger the overgrowth of algae, which can block sunlight, suffocate the system, and release harmful toxins (Anderson et al., 2021). The difficulty of treating aquatic systems impacted by contaminants such as nitrates and phosphates is rooted in their ionic state and the method of treatment traditional water treatment facilities use. Currently, one of the primary methods to treat water in the United States is oxidation (CDC, 2020), which is ineffective on nitrates and phosphates due to their fully oxidized state, however bio-based absorbents have shown promising results (Gizaw et al., 2021). With the risk of pollutants increasing globally, and especially in the U.S South, the need to integrate effective and sustainable treatment methods such as forest bio-based treatment has never been greater.

To this end, the demand for the forest products industry to innovate and produce sustainable materials such as bio-based water treatment materials, bio-degradable packaging products and biofuel is substantial. Additionally, by innovating the industry in this direction not only will Alabama’s forest products industry have the potential to increase profits but will also help the state achieve additional SDGs including 9: industry, innovation and infrastructure, 6: clean water and sanitation, 12: responsible consumption and production, 13: climate action and 7: affordable clean energy (Figure 12).

Figure 0-12: Alabama's progress towards SDG 9, 6, 12, 13 and 7 (Lynch & Sachs, 2021)

It is clear that there is potential for the forest products industry to help Alabama and the U.S address economic sustainable development goals, however, there is also opportunity to address societal inequities as well. Alabama's woodlands highest density exists within the Black Belt (Cartographic Research Lab Department of Geography University of Alabama, 2007), specifically loblolly plantations which are economically favorable species (Ruefenacht et al., n.d.). The Black Belt region within Alabama, while not well defined, primarily stretches across the south-central area of the state, as represented by Figure 13 by (Katsinas et al., 2020).

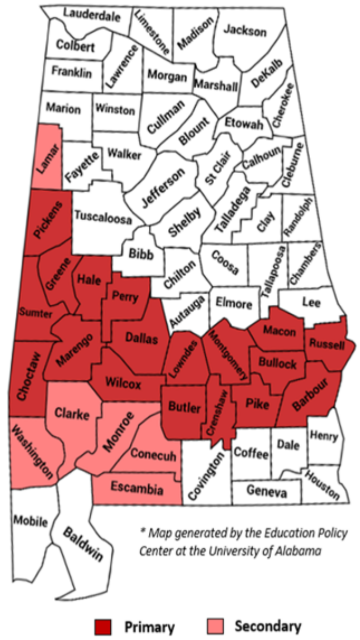

Figure 0-13: Visualization of Alabama's Black Belt Region (Katsinas et al., 2020).
Primary counties, represented in red, are counties that are represented by the majority of sources that the authors assessed, while secondary, represented in pink are mentioned less often, however are statistically consistent with variables often considered when defining the region.

Although the forest products industry is lucrative, the Black Belt has yet to see this economic prosperity (Archibald, 2022). Moreover, while the forest industry exists in this area, the representation of minorities in the field is extremely low (Sharik, 2015). In fact, the representation of minorities within the entire field of STEM (science, technology, engineering, and mathematics) is low. The National Science foundation reported that in 2021, only 15% of the U.S STEM workforce identified as Hispanic, 10% Asian, 9% Black and less than 1% identified as American Indians and Alaska Native (National Science Foundation, 2023). Previous studies found that minority students were reluctant to participate in pro-environmental activities and to choose careers in environmental fields (Christian et al., 2016; Christian et al., 2018). Studies conducted by Dutt (2020) and Yacoubian et al. (2017) found that minority students are less likely to pursue STEM studies and careers due to the lack of representation within the field. To address this issue Sheffield et al. (2021) studied the impact of exposing students to scientists of underrepresented backgrounds, and found by promoting diverse members of the field students were more likely to feel as though they "belong", and consider pursuing studies or careers in the field.

Therefore, it could be hypothesized that by providing students with educational resources focused on subjects and industries related to their environment, and promoting representation in these fields, both academic achievement and career exploration in environmental-related fields can improve. This approach aligns with the educational initiatives set forth by the UN (United Nations Educational, Scientific and Cultural Organization, 2015), and can be further enhanced by the educational frameworks proposed by evaluators (Kioupi & Voulvoulis, 2019; Kopnina, 2020; Pauw et al., 2015; Sinakou et al., 2019).

Moreover, developing relevant and impactful educational resources on the forest industry for vulnerable regions such as the Black Belt can significantly contribute to achieving several Sustainable Development Goals (SDGs). These include SDG 11) Make cities and human settlements inclusive, safe, resilient and sustainable, 10) Reduce inequality within and among countries, 8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all and 1) End poverty in all its forms everywhere (Figure 14) (Lynch & Sachs, 2021)

Figure 0-14: Alabama's progress toward SDG 11, 10, 8 and 1 (Lynch & Sachs, 2021)

Education on environmental topics like climate change and sustainability helps individuals understand the effects of climate change, the principles of sustainability, and the importance of adopting sustainable practices. Teaching citizens about solutions and practices available in their own communities can inspire changes at political, industrial, and household levels, as highlighted in the fourth Sustainable Development Goal (Martin, n.d.). Despite this understanding, many states, including Alabama, have not successfully incorporated these principles into their educational standards. Currently, Alabama is making less than 50% of the required progress towards quality education and faces significant challenges (Lynch & Sachs, 2021). The United States SDG Report (2021) identifies Alabama's biggest challenges as early education (K-12), literacy, and racial disparities (Lynch & Sachs, 2021). Figure 15 is a visual representation of Alabama's current standing in the fourth SDG: quality education.

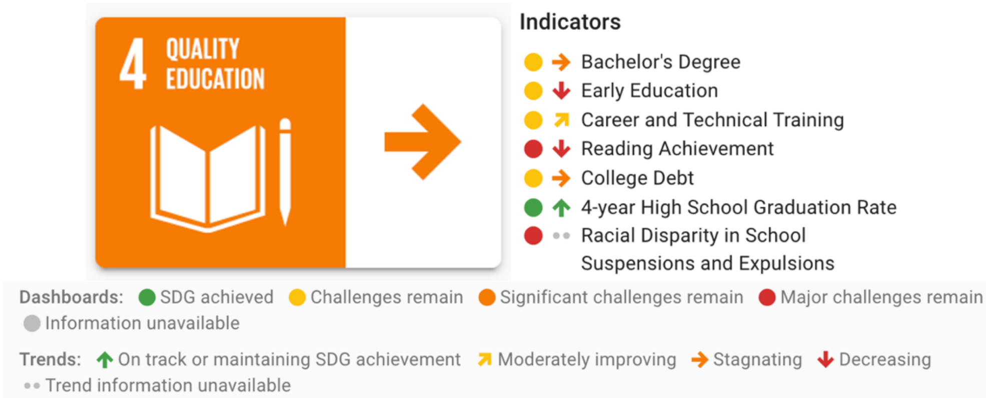

Figure 0-15: Alabama's current standing in the fourth SDG: quality education (Lynch & Sachs, 2021)

In 2020 Alabama was one of six states in the U.S to receive an "F" (failure) in effectively teaching the causes and consequences of a changing climate according to the National Center for Science Education (National Center for Science Education, 2020). Within this review, researchers state that the biggest failures within Alabama's curriculum regarding climate change and sustainability include the downplaying of human behavior (as a cause of climate change), not assessing the risks and immediacy of the issue, and not promoting critical thinking or responsible participation in civic deliberation.

The failure to meaningfully address climate change in educational standards is not a reflection of concerns of Alabama's public. A study conducted by Yale in 2021 assessed public opinions of climate change and policy across the United States (Marlon et al., 2021). According to this study, 63% of Alabamians believe global warming is happening, 58% are worried about global warming, and 74% believe schools should teach about global warming. It is important to note that the highest concentration of positive responses to these three questions are concentrated within the Black Belt Region. Overall, there is a demand for Alabama to teach climate change and sustainable principals in schools, however more work is needed to strengthen educational standards and develop effective educational resources related to these topics.

The call to integrate meaningful and impactful science education resources in Alabama is not only critical in consideration to elevated climate change risks, but also to the epidemic of science illiteracy in the state. Alabama's K-12 students have consistently scored below the national average on standardized achievement tests in Alabama (NAEP, 2019). According to the Public Affairs Research Council of Alabama, the overall proficiency rate for science has been constantly less than 40% in the nine years (Dailey, 2020). Research on the state has also been conducted on a national level. According to the National Center for Educational Progress (NAEP), only 24% of Alabama schools performed at or above proficiency level in 2019 (NAEP, 2019).

The low scores in science are of deep concern for Alabama and the country. Science education develops problem-solving skills, reasoning, curiosity, critical thinking, and measurement skills, all of which are necessary to promote sustainable practices (Martin, n.d.). Additionally, with the climate change risks the state is predicted to experience (US EPA, 2016), along with the large percentage of vulnerable rural communities (Stalnaker, 2012), environmental education is needed for students to understand the world around them, the changes they can make to mitigate these challenges, and the educational and career opportunities they, perhaps unknowingly, have in their backyards.

When developing sustainable educational initiatives, it is important to consider vulnerable populations within the state. Rural schools significantly make up Alabama education system, however reports find that Alabama struggles to adequately support these districts (Lindahl, 2018). A study conducted by Anderson (2016) found that rural schools in Alabama have consistently ranked low in academic achievement, which may directly correlate to lower funding and economic resources. Funding is used for building upkeep, salaries, supplies, and educational programs. Moreover, effective science teaching and learning are supported by hands-on activities (Kontra et al., 2015), which often rely on funded materials; thus, effective learning may not be financially possible in rural areas.

It is also critical to consider the socio-economic and demographic characteristics of rural areas in Alabama. These rural schools are predominantly comprised of minority students, with a significant number of African American students (Robson et al., 2019). The high presence of African American students in rural areas, especially in the Black Belt, is directly linked to historical inequities and systemic racism (A. Anderson, 2016; Mann & Rogers, 2021;Robson et al., 2019). The systemic challenges faced by the Black Belt region have led to higher environmental injustice indexes (Holifield, 2023), amplifying the need for environmental stewardship and justice in this region and across the state. Therefore, developing educational resources that address climate change and sustainability, and are specifically equitable and impactful for vulnerable populations, has never been more critical.

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Research Problem and Motivation of this Work

1.7 Research Problem:

The call for sustainability has never been greater due to increasing global temperatures and the risks associated with climate change. The U.S is struggling to progress towards sustainability, especially in the Southeast. Equitable education is an essential component to harvest sustainability, and the demand to initiate conversation about climate change and sustainability within schools is substantial, especially in areas of need within the Southeast. Alabama, a Southeastern state with great economic and social stake in environmental stability, faces its own challenges, especially in education. Alabama's education system struggles to produce academic achievement, especially in science education. Moreover, previous research suggests that historical inequities and the current funding of Alabama's education system has neglected to serve diverse populations who are directly impacted by the environment, both geographically and economically. Additionally, Alabama's economy relies heavily on the forest products industry, and its geographic location places it in a position to experience enhanced environmental degradation through climate change. Although at risk, the forest products industry also presents sustainable solutions to help mitigate climate change and the environmental challenges it presents, such as contamination of freshwater systems. To help enhance environmental awareness and science achievement in schools and support rural areas, developing equitable learning materials and programs relating to environmental science for all students and educators are necessary.

1.8 Motivation

The purpose of this study is to further understand the educational inequities within Alabama's education system and to develop learning material related to sustainability that is impactful, relevant, and inclusive to all students within the state.

1.9 Overall Objective

The primary objective of this study is to address and mitigate the educational inequities within Alabama's education system by developing and implementing inclusive, relevant, and impactful learning materials focused on sustainability. This objective aims to enhance environmental awareness and academic achievement in science, particularly for students in underrepresented and geographically vulnerable areas. By fostering equitable education and promoting sustainability within schools, the study seeks to prepare students to better understand and address the environmental challenges exacerbated by climate change, thereby contributing to the long-term economic and environmental stability of Alabama.

1.10 Objective 1

To assess the equity of science education in the state of Alabama by evaluating the relationships and comparing science proficiency scores, demographics, funding, expenditures, student achievement (college career readiness, and graduation rate), and chronic absenteeism between Black Belt and Non-Black Belt Schools.

Hypothesis: We hypothesize that the quality and equity of science education in Alabama can be determined through the assessment of these variables.

1.11 Objective 2

To assess the impact of a relevant-problem based active learning lesson on the use of bio-based materials remediating contaminated water on increasing students understanding of concepts related to environmental sustainability, environmental awareness and career interests.

Hypothesis: By developing this lesson, we hypothesize that this educational initiative will nurture environmentally aware and motivated citizens of the future.

1.12 Objective 3

To develop an outdoor community event with active-learning experiences to build confidence and promote change towards environmental awareness and sustainable practices.

Hypothesis: We hypothesize that by exposing community members to sustainable concepts and practices they will be more likely to understand these concepts and implement them into their lives.

1.13 Objective 4

To understand how a minority-focused mentorship group impacts student's educational achievement and post-secondary interest in STEM.

Hypothesis: We hypothesize that outreach and minority representation in the field of STEM can increase student interest and participation in science.

Framework and Approach

To address educational disparities and sustainable development in Alabama, it is essential to center research objectives and methodologies around literature-based frameworks, theories and models. With the purpose of this work focusing on addressing educational inequities and promoting learning, the frameworks considered in this study include those related to gap assessment, formal classroom learning, informal learning, and outreach (Figure 1).

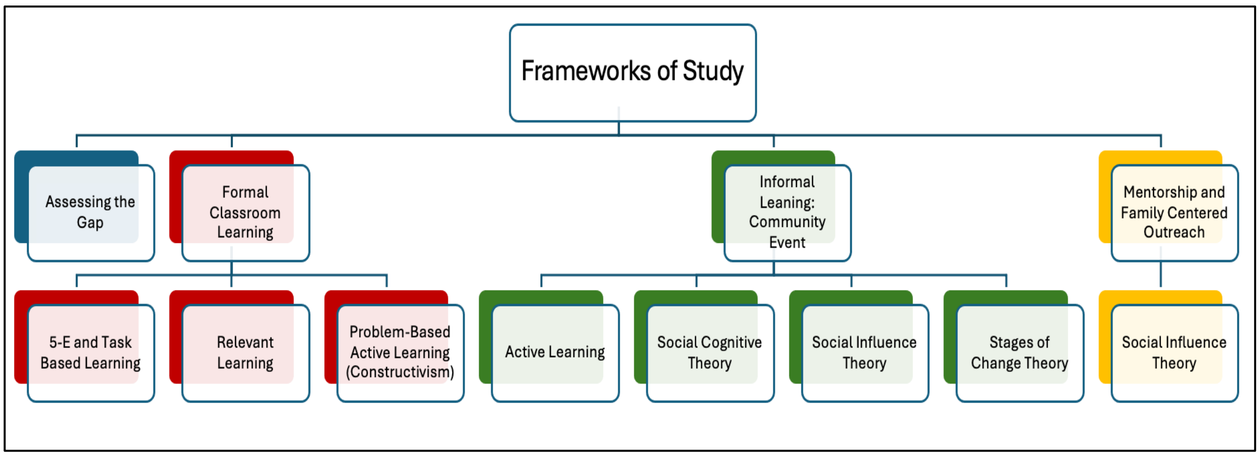

Figure 0-1: Visualization of Frameworks Used Within the Study: Visualization of the frameworks used to develop the methodologies of this study; centered around gap assessment, formal education, informal education and outreach.

1.14 Gap Assessment

To begin developing impactful educational resources and outreach, it is essential to evaluate the gap of science education within the state. Through this analysis, it is critical to consider historical disparities and marginalized populations, particularly the Black Belt Region. Gap assessments are a common method used in many fields to evaluate the current standing of an organization or program, compared to its aim (Kim & Ji, 2018). Gap assessments can be conducted through several methods, including comparisons amongst groups, importance-performance analysis, correlations, regressions, and descriptive statistics. With SDG4 emphasizing the need for equitable education, comparing the differences amongst historically marginalized areas (the Black Belt) with the rest of the state is critical. Conducting a gap analysis will allow for a better understanding of the disparities that exist, leading the way for targeted educational resources to be developed.

1.15 Formal Classroom Learning Frameworks

1.15.1 Relevant Learning

A lesson is only impactful if it is implemented and taught in effective ways. Many studies have been conducted to develop effective learning strategies; one such strategy is relevant learning. Relevant learning involves subjects and materials that are tailored to be relatable to learners' lives, emotions, or interests (Willis, 2007). A psychological study by Judy Willis (2007) found that students are more likely to remember and become interested in the material when it relates to their personal lives and emotions. Moreover, the same study found that stress and anxiety increase when the learning material is irrelevant to students. When the research team assessed the brain's functionality under stress, they found that the area responsible for higher cognitive memory, consolidation, and storage was inhibited. When students learn material that connects to their lives and interests, stress was significantly absent, and the areas of the brain that promote focus and memory were activated. Therefore, when relevant teaching is applied, students experience a higher chance of learning and retention.

1.15.2 Problem-Based, Active Learning

Another learning strategy is problem-based active learning. Active learning derives from the theory of Constructivism, which was developed by Jean Piaget (Kimmons & Caskurlu, 2020; Mascolo & Fischer, 2010). Piaget’s theory states that individuals develop knowledge through the interaction between their experiences and ideas, rather than passively. To this end learning is promoted through physical experiences, led by students. In more recent work, researchers have found that this theory is strengthened with the exploration of relevant problems and solutions, also known as problem-based learning (PBL) (Akınoğlu & Tandoğan, 2007; Kontra et al., 2015). PBL approaches develop learning environments in which the students are responsible for developing a solution to a presented problem; they develop and assess their predictions through hands-on activities. Hands-on activities stimulate motor-related areas of the brain, and when practiced, studies have shown that active-learning correlates to higher assessment scores in students (Kontra et al., 2015). Moreover, problem-based active learning stimulates critical thinking, communication, and time management skills (Akınoğlu & Tandoğan, 2007). Problem-based active learning is an effective teaching strategy that increases students' academic success and skill sets.

1.15.2.1 Relevance and Constructivism of Lessons Centered Around Alabama Woodlands and Forest Products

The subject of forestry is a relevant environmental science topic that students in Alabama can connect and relate to. With over 23 million acres of forest land, covering about 70% of the state (Randle, 2020), many students in Alabama are familiar with forests and the forest products industry. The Black Belt, an area with significant challenges in science proficiency and environmental justice, has the highest density of woodlands, making forestry education particularly relevant and inclusive (Andrew J. Hartsell, 2015; Cartographic Research Lab Department of Geography University of Alabama, 2007). The forest products industry's reliance on environmental sustainability for economic viability underscores the importance of teaching these principles through engaging, problem-based learning to foster meaningful and effective educational experiences.

To integrate active, problem-based pedagogy, the proposed lesson will focus on the engineering and production of sustainable forest products, specifically the development and effectiveness of bio-based water treatment materials. Water quality is a critical subject for all students due to its universal importance for survival and well-being. In Alabama, the relevance is heightened as the state is highly susceptible to fertilizer, wastewater and stormwater pollution, which can cause eutrophic conditions in aquatic environments (Gurung et al., 2013; Mirhosseini & Srivastava, 2016). Due to the fully oxidized state of the nitrates and phosphates that cause eutrophication, these contaminants cannot be treated by traditional water remediation methods such as oxidation, however they can be remediated through the sorption techniques of forest-products (Gizaw et al., 2021). To this end, the lesson will explore eutrophication, its link to human-induced climate change and agricultural practices, the potential of bio-based water treatment methods, and Alabama's role in their development. Students will engage in discussions, design bio-based filters, test contaminated water, and propose solutions to mitigate eutrophication in Alabama.

Moreover, to make ensure this lesson will be suitable in classroom settings the following environmental science state standards will be addressed (Alabama Learning Exchange, n.d):

a) Engage in argument from evidence to evaluate how biological or physical changes within ecosystems (e.g., ecological succession, seasonal flooding, volcanic eruptions) affect the number and types of organisms, and that changing conditions may result in a new or altered ecosystem.

b) Develop and use models to trace the flow of water, nitrogen, and phosphorus through the hydrosphere, atmosphere, geosphere, and biosphere.

c) Design solutions for the protection of natural water resources (e.g., bioassessment, methods of water treatment and conservation) considering properties, uses, and pollutants (e.g., eutrophication, industrial effluents, agricultural runoffs, point, and nonpoint pollution resources).

In conclusion, this lesson will be centered around a relevant environmental problem that students will solve by actively making and testing a bio-based water filter (a locally relevant solution).

1.16 Lesson Plan Frameworks

When developing a lesson educators first construct lesson plans to guide their teaching and planning. Lesson plans center around curriculum standards and are often structured around evidence-based frameworks that support learning. Two lesson-plan frameworks that complement the theories of constructivism and relevance are Task-based learning (TBL), and 5-E's.

1.16.1 Task-Based Learning (TBL)

TBL in science classes is an educational framework that focuses on engaging students through the completion of meaningful and relevant tasks (Zhou et al., 2013). Tasks are defined as activities that require learners to use language or other skills to achieve a specific outcome. In science classes, tasks are often hands-on experiments, projects, or problem-solving activities that mimic real-world scientific inquiries. TBL often begins with a pre-task where teachers introduce the topic, providing any necessary background information to ensure students understand the context and purpose of the task. Additionally, within the preliminary tasks students may discuss what they know about the topic, brainstorm ideas, formulate hypotheses and plan their approach to completing the primary activity.

Primary tasks seek to engage students in hands-on activities by conducting experiments, collecting data, and making observations. The intention of the primary task is for students to lead their own scientific methods and apply knowledge to solve problems or answer questions. Furthermore, during this phase, students work together, share ideas, and communicate their findings. This collaborative aspect helps them learn from each other and refine their understanding. Following the primary task, students will present their findings and results through the development of lab reports, presentations, class discussion or constructing models. The objective of the post-task is for students to articulate their process, results, and conclusions clearly. Overall, TBL fosters critical thinking, problem-solving, and collaborative skills with students learning how to design experiments, analyze data, and communicate their findings effectively. To this end, TBL aligns with constructivist theories of learning, where students build their knowledge through active exploration and interaction with their environment.

1.16.2 The 5-E's

The 5-E lesson plan is a teaching model designed to promote active learning and constructivism (Rodger W. Bybee, 2015). The structure of this model seeks to encourage students to build their understanding of concepts through five phases: engagement, exploration, explanation, elaboration, and evaluation. This model is widely used in science education to enhance students' comprehension and retention of material. The first phase, engage, seeks to capture students' interest and stimulate their curiosity. Engagement can be performed in many ways including demonstrations, asking questions and facilitating debate or discussion. In the second phase, explore, students will begin to investigate the topic through hands-on experiences. Following exploration, students will explain their findings and results using their background knowledge or information they learned within the lesson. Additionally, within this phase, teachers may introduce term definitions, and explanations. Following the explanation, elaborate, students will apply what they have learned through an additional activity, which may include comparisons of results, discussions, or real-world applications. Lastly, student activities and results will be evaluated by teachers to assess what has been learned and to determine what can be improved upon.

1.16.3 Blending 5-E and Tasked-Based Learning Models:

Developing a lesson plan that integrates both task-based learning and the 5-E model can promote learning and academic success by combining the strengths of both approaches. Task-based learning emphasizes practical application and problem-solving, allowing students to engage in meaningful activities that reflect real-world challenges. This hands-on approach helps students to understand and retain knowledge more effectively by doing, which is reinforced by the active exploration phase of the 5-E model. The 5-E lesson plan further scaffolds learning by guiding students through a structured sequence: engaging their interest, exploring concepts through inquiry and experimentation, explaining their understanding, elaborating on their knowledge through application, and evaluating their progress. This comprehensive framework not only stimulates curiosity and fosters deeper understanding but also accommodates different learning styles and paces, ensuring that all students can participate and benefit. By incorporating both methods, educators can create a dynamic and interactive learning environment that promotes critical thinking, enhances retention, and supports long-term academic success.

1.17 Community Outreach Frameworks

Without outreach, educational success, resources, and representation would be difficult to ensure. Christian et al. (2018) who studied the perspectives and experiences of high school students towards the environment in the state of Alabama, found that there is a need to design broad environmental literacy and outreach programs in order to motivate and enhance knowledge and significantly increase awareness and involvement of students from minority communities in various fields of environmental science (Christian et al., 2018). Previous studies on outreach programs and events have shown promising results in promoting learning and change. To begin, studies shared by Wagner et al. (2022) showed dramatic academic achievement improvements in diverse communities when community programs and events were provided to students (Wagner et al., 2022).

Community events are a form of informal learning which is defined as an educational experience that can take place outside of a traditional learning environment and may involve individuals, families, or social groups (Bell et al., 2016). In 2016, Lin and Schunn conducted a study to measure the effect of informal learning on over 2900 children in sixth and eighth grade (Lin & Schunn, 2016). Through their research, they found that informal learning experiences can have positive impacts on students' attitudes and abilities in science education. Moreover, informal learning that occurred outdoors or within nature proved highly effective in this study. This finding is also supported by research developed by Sadler et al. (2010), who noted that students who explore nature have a greater chance of developing self-efficacy, problem-solving skills, and interest in science-related fields (Sadler et al., 2010).

The success of community outreach complements what is known about several psychological theories and frameworks including Stages of Change Theory, Social Cognitive Theory, and Social Influence Theory.

1.17.1 Stages of Change

Researchers, Prochaska, DiClemente and Norcross introduced the Stages of Change Theory in 1992 (Prochaska et al., 1992). This theory posits that individuals go through five stages as they begin to adopt a new behavior or belief including, pre-contemplation (not yet considered changing), contemplation (recognize the need for change), action (modification of behavior), maintenance (sustain the new behavior). Stages of Change Theory helps tailor outreach efforts to individuals' readiness to change by recognizing and addressing the distinct phases of change than individuals are in. By understanding these stages, outreach programs can provide appropriate support and interventions at each step, facilitating gradual and sustained behavioral change.

1.17.2 Social Cognitive Theory and Active Learning

The Social Cognitive Theory, which was developed by Albert Bandura in 1986, states that self-efficacy is affected by individuals' self-confidence to control or perform the action (Bandura, 1986). Outreach programs leverage this by showcasing role models, creating supportive environments, and enhancing individuals' confidence in their ability to make changes. Furthermore, outreach events that incorporate active learning activates can develop individual's self-confidence to perform and enact change.

1.17.3 Social Influence Theory

The Social Influence theory, developed by Herbert Kelman, states that people are heavily influenced by the thoughts and actions of others. This theory explains that individuals' behaviors and attitudes are influenced through compliance (adopting behavior for fulfill expectations), identification (conforming to others), and internalization (adopting behavior that aligns with personal values) (Kelman, 1958). Overall, the Social Influence Theory highlights the impact of social networks and relationships on behavior. Community outreach initiatives harness this by engaging community leaders and influencers, fostering peer support groups, and building strong social connections to encourage and sustain positive behaviors.

Together, these theories provide a robust framework for designing effective community outreach programs that inspire and support meaningful change.

1.18 Mentorship Outreach Framework

Studies have shown that mentorship programs have increased college attendance in minority students. DuBois et al. (2011) conducted a study on 73 individual mentorship programs to study their effects on children's social, behavioral, emotional, and academic well-being. Through their research, it was found that mentorship programs have a positive effect on the variables studied, including academic success (DuBois et al., 2011). Additionally, a similar study conducted by Rodriguez-Planas in 2012 found that there are positive long-term effects of mentorship programs on students as well, with students who participated in mentorship programs having a higher chance of graduating high school and pursuing post-secondary education. Moreover, the Centre for Addiction and Mental Health and Big Brothers Big Sisters Canada found that mentored boys are twice as likely to believe that school is "fun" and that doing well academically is "important" (Centre for Addiction and Mental Health, 2013). Overall, having an accomplished peer to guide and motivate students has shown promising results. Overall, mentorship presents as a promising reassures in addressing potential gaps in science education, as well as the lack of diversity present in scientific fields (National Science Foundation, 2023).

1.18.1 Social Influence Theory

Mentorship programs closely align with Social Influence Theory, which posits that individuals' behaviors, attitudes, and beliefs are significantly shaped by their social interactions and relationships. In the context of mentorship, mentors serve as influential figures who can model desired behaviors, provide guidance, and offer support to mentees. To this end, studying the impacts of mentorship with the consideration of Social Influence Theory, can help bridge the gap in STEM education and lack of diversity by highlighting how influential role models and supportive relationships can encourage underrepresented students to pursue and succeed in STEM careers.

1.19 Conclusions

Introducing educational and psychological frameworks to promote science education and sustainability in Alabama is crucial for addressing the state's unique challenges. Utilizing gap assessment allows educators to identify disparities between historically marginalized regions. By understanding the gap, relevant learning material can be developed and implemented through formal learning frameworks such as the 5-E model (Engage, Explore, Explain, Elaborate, Evaluate) and task-based lesson plans that emphasize constructivism. These approaches create a structured yet flexible environment that supports active learning and critical thinking. Furthermore, community outreach and informal learning, supported by social influence theory, constructivism, stages of change theory, and social cognitive theory, provides additional opportunities for students to engage with scientific concepts outside the traditional classroom setting. Lastly, mentorship, also grounded in social influence theory, can further enhance these efforts by connecting students with role models who can inspire and guide them. By integrating these frameworks, Alabama can cultivate a more diverse and proficient science-based workforce, driving sustainable development and innovation in the state.

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Methodology

This dissertation consists of four distinct studies aimed at exploring various educational outcomes and interventions in different school districts and settings. Each study employed a unique methodology tailored to its specific research objectives, however, there are several common elements in data collection, statistical analysis, and recruitment amongst each study.

1.21 Defining Study Boundaries

For studies involving geographical distinctions, clear boundaries were established using multiple sources. Specifically, the Black Belt region's boundaries were determined by collecting definitions from eight different organizations (Alabama Black Belt Adventures Association, 2022; Alabama Black Belt Heritage Area, n.d; Alabama Department of Economic and Community Affairs, n.d.; Alabama Department of Public Health, 2020; Black Belt Community Foundation, n.d.; Katsinas et al., 2023; The Office of Primary Care and Rural Health, Alabama Department of Public Health and The Alabama Rural Health Association, 2007; Winemiller, 2023), and selecting counties represented by at least half of these sources. This ensured a consistent and reliable classification of school districts into Black Belt (BBSD) and Non-Black Belt school districts (NBBSD).

Following the evaluation of eight different sources, 21 counties were chosen as members of the Black Belt, as they each were represented by at least half of the sources. A table of each county with the sources evaluated, and a visual representation of the Black Belt can be seen in Table 1 and Figure 1, respectively.

Table 0-1: Black Belt Counties

	The Alabama Encyclopedia “Traditional Counties” [1]	Delta Regional Commission [2]	Alabama Black Belt Adventures [3]	Black Belt Action Commission [4]	Alabama Department of Public Health [5]	Black Belt Community Foundation [6]	Alabama Black Belt Heritage Area [7]	University of Alabama Education Policy Center Definition [8]	Total
Barbour	✓	✓	✓		✓			✓	5
Bibb							✓		1
Bullock	✓	✓	✓	✓	✓	✓	✓	✓	8
Butler	✓	✓	✓		✓		✓	✓	6
Choctaw	✓	✓	✓	✓	✓	✓	✓	✓	8
Clarke		✓	✓				✓	✓	4
Conecuh		✓	✓				✓	✓	4
Crenshaw	✓		✓		✓			✓	4
Dallas	✓	✓	✓	✓	✓	✓	✓	✓	8
Escambia		✓						✓	2
Greene	✓	✓	✓	✓	✓	✓	✓	✓	8
Hale	✓		✓	✓	✓	✓	✓	✓	7
Lamar								✓	1
Lee			✓						1
Lowndes	✓	✓	✓	✓	✓	✓	✓	✓	8
Macon	✓	✓	✓	✓	✓	✓	✓	✓	8
Marengo	✓	✓	✓	✓	✓	✓	✓	✓	8
Monroe		✓	✓				✓	✓	4
Montgomery	✓		✓		✓		✓	✓	5
Perry	✓	✓	✓	✓	✓	✓	✓	✓	8
Pickens		✓	✓	✓	✓	✓	✓	✓	7
Pike	✓		✓		✓			✓	4
Russell	✓	✓	✓		✓			✓	4
Sumter	✓	✓	✓	✓	✓	✓	✓	✓	8
Tuscaloosa			✓						1
Washington		✓					✓	✓	3
Wilcox	✓	✓	✓	✓	✓	✓	✓	✓	8

Note: Counties cited by organizations and literature as “Black Belt Counties”. Counties highlighted in yellow are those that have been selected in the study, as they are represented at least half of the literature and organizations assessed. [1] (Terance L. Winemiller, 2023) [2]

(Alabama Department of Economic and Community Affairs, n.d.) [3] (Alabama Black Belt Adventures Association, 2022.) [4] (The Office of Primary Care and Rural Health, Alabama Department of Public Health and The Alabama Rural Health Association, 2007)[5] (Alabama Department of Public Health, 2020) [6](Black Belt Community Foundation, n.d.) [7](Alabama Black Belt Heritage Area, n.d) [8](Katsinas et al., 2023)

Figure 0-1: Black Belt Region Used In This Study, by County

After determining which counties were located within the Black Belt, the school districts that fell within each county were identified and are listed in Table 2.

Table 0-2: School Districts That Fall Within Black Belt Counties That Were Selected for the Study.

County	School Districts		
Barbour	Barbour Country School District	Eufaula City School District	
Bullock	Bullock County School District		
Butler	Butler County School District		
Choctaw	Choctaw County School District		
Clarke	Clarke County School District	Thomasville City School District	
Conecuh	Conecuh County School District		
Crenshaw	Crenshaw County School District		
Dallas	Dallas County School District	Selma City School District	
Greene	Greene County School District		
Hale	Hale County School District		
Lowndes	Lowndes County School District		
Macon	Macon County School District		
Monroe	Monroe County School District		
Marengo	Marengo County School District	Linden City School District	Demopolis City School District
Montgomery	Montgomery County School District	Pike Road City School District	
Perry	Perry County School District		
Pickens	Pickens County School District		
Pike	Pike County School District	Troy City School District	
Russell	Russell County School District	Phenix City School District	
Sumter	Sumter County School District		
Wilcox	Wilcox County School District		

1.22 School District Data Collection:

The following variables were collected from the 2021-2022 fiscal year. Overall, 138 public school districts in Alabama were considered, charter schools, day schools, military bases and online academies were omitted. Table 3 shows a complete list of variables, their definitions, and their sources. Overall data collected centered around the following:

- **Student and Teacher Demographics**: Information on student racial and ethnic populations, total student and teacher populations, student-teacher ratios, minority student populations, students with disabilities, students with limited English proficiency, and economically disadvantaged students.
- **Funding and Expenditures**: State, federal, local, school revenue, and other per-pupil expenditures (PPE), as well the expenditures from each category were collected from each district.
- **Academic Achievement and Attendance**: Student performance metrics (science proficiency, college career readiness, and graduation rate), chronic absenteeism rates, and other academic indicators were collected as they related to SDG4 (work force development, understanding of sustainability, and school accessibility).

Table 0-3 School District Variables Collected and Their Sources

Variable	**Sub-Variables**	**Definition**	**Source**
Student Demographics	White Student Population (%)	Percentage of students within the district that identify as White.	(Alabama Department of Education, 2022c)
	Black or African American Population (%)	Percentage of students within the district that identify as Black or African American.	(Alabama Department of Education, 2022c)
	Two or More Races (%)	Percentage of students within the district that identify with two or more races.	(Alabama Department of

			Education, 2022c)
	Indigenous Student Population (%)	Percentage of students within the district that identify as American Indian/Alaska Native, or Native Hawaiian/Pacific Islander.	(Alabama Department of Education, 2022c)
	Asian Student Population (%)	Percentage of students within the district that identify as Asian.	(Alabama Department of Education, 2022c)
	Hispanic/Latino Population (%)	Percentage of students within the district that identify as Hispanic and or Latino.	(Alabama Department of Education, 2022c)
	Total Minority Population (%)	Percentage of students within the district that identify as a minority (Black or African American, Asian, Indigenous, Hispanic/Latino and or two or more races)	(Alabama Department of Education, 2022c)
	Students with Limited English Proficiency (%)	Percentage of students within the district that are not fluent in English, and who has limited ability to read, write, speak, or understand English.	(Alabama Department of Education, 2022c)
	Students with Disabilities Population (%)	Percentage of students within the district who have physical, emotional, learning, or cognitive disabilities and who, by reason of the condition, needs special education or related services.	(Alabama Department of Education, 2022c)
	Economically Disadvantaged Student Population (%)	Percentage of students within the district who are from low-income households.	(Alabama Department of Education, 2022c)
Funding Per Pupil Expenditure (PPE)	State PPE	State funds spent per student.	(Alabama Department of Education, 2022b)
	Federal PPE	Federal funds spent per student.	(Alabama Department of Education, 2022b)
	Local PPE	Local funds spent per student.	(Alabama Department of Education, 2022b)
	Local School Revenue PPE	Local school revenue funds spent per student.	(Alabama Department of Education, 2022b)
	Other PPE funds	Other funds spent per student.	(Alabama Department of Education, 2022b
	Total PPE	Overall amount spent per student.	(Alabama Department of Education, 2022b)
Per Pupil Expenditures (PPE)	Instructional Services PPE	Amount spent per student on any learning activity, resource or experience with a teacher, teaching assistant or substitute.	(Alabama Department of Education, 2022b)
	Student Support	Amount spent per student on activities	(Alabama

	Services PPE	aimed at enhancing student well-being and academic success.	Department of Education, 2022b)
	Instructional Staff Support PPE	Amount spent per student to support teacher resources and professional development.	(Alabama Department of Education, 2022b)
	School Administrative Services PPE	Amount spent per student on functions dedicated to the management and administration for each school.	(Alabama Department of Education, 2022b)
	Total Instructional Support PPE	Amount spent per student for instructional services, student support services, instructional staff support and school administrative services.	(Alabama Department of Education, 2022b)
	Operations and Maintenance PPE	Amount spent per student or any services that provide maintenance to school buildings, grounds and technology.	(Alabama Department of Education, 2022b)
	Transportation Services PPE	Amount spent per student for educational transportation.	(Alabama Department of Education, 2022b)
	Food Service PPE	Amount spent per student for any activity or service related to providing food to students and staff.	(Alabama Department of Education, 2022b)
	Preschool PPE	Amount spent per student to provide special education for children aged 3-4 with disabilities.	(Alabama Department of Education, 2022b)
	General Administrative Services PPE	Amount spent per student or services and activities related to the board of education, policy, and governance.	(Alabama Department of Education, 2022b)
Student and Teacher Population	Total Students	Total student population within the school district.	(Alabama Department of Education, 2022b)
	Total Teachers	Total teacher population within the school district.	(Alabama Department of Education, 2022c)
	Student Teacher Ratio	The average amount of students per teacher in each school district.	(Alabama Department of Education, 2022b)
Title I School Classification	Title I School Classification	Whether or not a school meets the criteria and is funded through the Title I Federal program.	(Alabama Department of Education, 2021)
Academic Achievement	Science Proficiency (SP)		(Alabama STEM Council, 2022)
	College Career Readiness (CCR) (%)	Percentage of students who meet one or more of the following: score “college ready” in at least one subject on the ACT, score at the silver level or above on the WorkKeys Assessment, earn a passing score on an Advanced Placement or International Baccalaureate Exam, successfully earn a Career Technical Education credential. Earn, dual enrollment credit at a college or	(Alabama Department of Education, 2022c; Dailey, 2019)

		university, and/or successfully enlist in the military.	
	Graduation Rate (GR) (%)	Percentage of students who graduate within four (4) years of 1st entering the 9th grade.	(Alabama Department of Education, 2022c)
Chronic Absenteeism	Chronic Absenteeism (%)	Percentage of students in grades K-12 who missed a total of 18 or more days (excused or unexcused) of the time enrolled.	(Alabama Department of Education, 2022c)

1.23 Survey Development and Data Collection

Surveys were designed using Qualtrics to gather qualitative and quantitative feedback from participants of each intervention. These tools were validated for reliability and accuracy through a third party, and Institutional Review Board (IRB) approval was obtained for all human subjects research. Surveys included pre- and post-implementation versions to measure changes over time. Survey Data from Qualtrics was stored on an Excel Spreadsheet and transferred to Statistical Package for the Social Sciences (SPSS) for quantitative analysis. Overall data collected centered around the following:

- **Participant Demographics:** For studies involving the implementation of learning interventions, participant demographics were obtained through survey questions. Questions regarding racial and gender identity and educational background were taken from the Qualtrics validated questions library.
- **Program Implementation and Feedback**: Qualitative and quantitative questions were used to evaluate perceptions from educational professionals and participants to assess program relevance, impact, and equity.

1.24 Participant Recruitment

Participants were recruiting to participate in learning interventions through various methods including via email, social media, word-of mouth, and workshop training. The specific recruitment processes of each study are elaborated upon within their chapters.

1.25 Data Analysis

Quantitative data analyses were conducted using SPSS with a set alpha significance value of <.05 and a 95% confidence interval. The following statistical methods were used across the studies:

- **Cronbach's Alpha (α) :** used to assess the internal consistency or reliability of a set of scale or test items. Cronbach's Alpha was interpreted as $\alpha < .5$ unacceptable, $0.5 \leq \alpha < 0.6$ poor, $0.6 \leq \alpha < 0.7$ questionable, $0.7 \leq \alpha < 0.8$ acceptable, $0.8 \leq \alpha < 0.9$ good, and $0.9 \leq \alpha$ excellent.
- **Analysis of variance (ANOVA):** Used to evaluate differences in responses between groups.
- **Kruskal Walis:** In the event any ANOVA results violated the homogeneity of variance, a non-parametric Kruskal-Wallis test was performed to compare differences in response between groups.
- **Multivariate Analyses of Variance (MANOVA)**: Used to assess differences between groups across multiple dependent variables simultaneously, such as funding, demographics, and expenditures.

- **Pillai’s Trace:** When conducting MANOVA analyses, if the results of Box’s Test of Equality of Covariance Matrices had a significance value of <.001, Pillai’s Trace criterion was used since it is more robust to departures from assumptions.
- **Independent Samples T-Tests**: Used to compare means between two independent groups for various demographic, funding, expenditure, and academic achievement variables.
- **Paired Samples T-Test:** Used when comparing the difference in pre-post responses of the group of participants as a whole.
- **Chi-Square Tests**: Employed to examine the relationship between categorical variables, such as Title I classification and geographic region. Phi was used to calculate the effect size (>.25 very strong, >.15 strong, >.10 moderate >. 05 weak, <.05 none)
- **Cohen’s d, Effect Size:** used to measure the strength of a relationship, or effect size, between two groups or conditions by calculation how many standard deviations lie between the means of two groups. Cohen’s D effect size was interpreted as: 0.0-.20 weak, .21-.50 modest, .05-1.0 moderate, >1.0 strong.
- **Correlation Analyses**: Pearson's correlation coefficients were calculated to explore relationships between continuous variables like funding, expenditures, academic achievement, and chronic absenteeism. Correlation strengths were categorized as: 0-.39 (weak), .4-.59 (moderate), .6-.79 (high), .8-1.0 (very high).
- **Backward Stepwise Regression Analysis:** used to build models, related to student achievement and significantly correlated variables, by systematically removing the least statistically significant predictor variables. To do so, a criterion was set at a probability of F-to remove greater than or equal to .100.

- **Descriptive Statistics**: Means, standard deviations, and effect sizes (Cohen's D) were reported for all key variables.

For all quantitative results, mean results will be represented by "M", standard deviation, "SD", Cohen's D effect size,"d", t value, "t", Cronbach's Alpha, "α", F-value, "F", t-test degrees of freedom (df), "t (df)", regression degrees of freedom "F (regression df, residual df)", significance value, "p", Beta "b", adjusted R-squared "R^2".

Qualitative responses are evaluated through thematic analysis, where responses are transcribed, coded, and categorized to identify common themes and patterns. Open-ended feedback is systematically analyzed to extract meaningful insights and trends relevant to the study objectives.

1.26 Geospatial Analysis

For school district results, hotspot maps were developed using ArcGIS to visually represent the distribution of key variables across school districts and regions (Black Belt and Non-Black Belt). To do so, the excel spreadsheet with school district data (described in section 4.2) was uploaded on to ArcGIS and was joined and related by school district name to the "Alabama Public School Districts" raster, which is available on ArcGIS Pro Online. After each map was developed a red boundary line was drawn across the Black Belt boundary.

Limitations, Reliability and Validity

1.27 Limitations

Some limitations of the study included sample size, no-treatment control groups, time of day, and age of participants. Each study was dependent upon volunteers, which included teachers willing to implement the lesson in their classroom, families who were willing to share their perspectives and experiences, and community members willing to attended an event and take surveys. The researchers had no control over who signed up, although they actively recruited and performed multiple trials of each study to attempt to create fair sample sizes. Additionally, in all three studies, there were no non-treatment groups that did not experience the interventions studied. Moreover, since everyone has a different level of learning, it may be unethical to have compared our subjects to a non-treatment group.

In the first study, teachers implemented the lesson within their classrooms. In many traditional secondary schools, teachers may teach the same subject to different classes at different times of the day. The time of day might have presented limitations or influences on the learning experience. Additionally, in all three studies, participants varied in age. It is natural for a student to develop certain educational skills and knowledge over time; therefore, the results of each study are limited or impacted due to age

1.28 Reliability and Validity

To ensure reliability in all studies that use pre-post surveys, internal consistency will be developed by developing multiple Likert-scale questions that measure the same subject to see if the participant will exude consistent understanding. Cronbach's Alpha was performed on each of these questions to measure the internal consistency and reliability of responses. To ensure validity, construct and internal validity was used. Internal validity seeks to understand the cause-and-effect relationship between the variables of the study, making it suitable to validate the impact our educational resources have on participants (Hufford, 2021). To achieve this, specific questions were asked to ensure that the intervention was the cause of any changes observed. Construct validity seeks to ensure that the survey measures the concept it was designed to measure. To ensure construct validity surveys were evaluated by third parties. By applying these methods, the research team was able to ensure that the study and effects of the developed resources were valid.

1.29 Threats to Internal Validity

There were several threats to the internal validity of the studies, including history, maturation, and testing (Bhandari, 2020). History involved unrelated events that may influence outcomes. Factors of participants' lives might have added mental and physical conditions that could have affected their performance or experiences in any of the studies. Maturation is when results vary as a natural result of time. Although timing was considered in each study when developing educational resources and experiences, the students and participants involved in these lessons, events, and mentorship programs varied in age. As mentioned previous, it is natural for a student to develop certain educational skills and knowledge over time; this maturation process might have influenced their experience and understanding in each study. Lastly, the pre-test in the first study had the same questions as the post-test. Although this adds consistency, participants may show higher proficiency in the post-test since they know what questions will be asked.

1.30 Ethical Considerations

Each study's design was sent to the IRB for approval before each program's implementation. The IRB assessed the studies methodology to ensure all ethical standards were met. In all studies, participants were provided with a consent form prior to the intervention or collection of data. Consent forms included detailed information on the study and their rights as a participant. Participants were required to agree to the consent form in order to participate in the studies. Participation in all studies was voluntary, and all were welcome to participate in the interventions. For the mentorship study, if a participant was under the age of 18, their legal guardian was required to approve and sign their consent documentation.

In all studies, the names of each participant remained confidential. Each participant received a code or pseudonym assigned by the primary researcher; the document which organizes the name to the code was be stored in a secure Auburn University (AU) Box Drive. Similarly, all data collected from research instruments was stored in a secure AU Box Drive. Although secure, there is always a chance of a breach of confidentiality, which was stated within consent documents. Moreover, all activities involved in the studies did not put any participants at harm or in a compromising position in any way. Lastly, subjects were free to remove themselves from the study at any time; moreover, their choice to withdraw did not harm their relationship with the researchers, Auburn University, or any of the programs involved. This information was clearly stated within the consent documents.

1.31 Literature Cited

Bhandari, P. (2020, May 1). *Internal Validity in Research | Definition, Threats, & Examples*. Scribbr. https://www.scribbr.com/methodology/internal-validity/

Hufford, B. (2021, January 2). *The 4 Types of Validity in Research Design (+3 More to Consider)*. https://www.activecampaign.com/blog/validity-in-research-design

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Comparative Analysis of Educational Disparities in Alabama’s Black Belt vs. Non-Black Belt School Districts

1.32 Abstract:

Science education and proficiency are crucial for sustainable development. Alabama, facing significant challenges in sustainable development and environmental risks, has a history of educational inequalities. Prior research indicates underfunded and inaccessible education in rural minority communities, particularly in the Black Belt region. This study aims to evaluate academic achievement related to sustainable development (science proficiency, graduation rate and college readiness) funding, expenditures, student demographics, and absenteeism in Alabama, by comparing Black Belt and Non-Black Belt school districts. Data from the 2021-2022 academic year were collected and analyzed using statistical evaluations, correlations and regression analyses. Results reveal differences in resource allocation, educational outcomes, and socio-economic conditions, particularly in the historically marginalized Black Belt region. While the Black Belt receives increased funding, educational achievements in this region remain inadequate. Additionally, our results find that higher science proficiency correlates with increased graduation rates and college readiness, highlighting its importance for workforce and sustainable development. This study sheds light on educational disparities and underscores the critical role of science education in fostering sustainability.

Keywords: Sustainability, Equitable Education, Alabama, Science Proficiency.

1.33 Background and Introduction:

Sustainable development involves the balance of social, economic, and environmental principles to sustain present and future generations (U.S Environmental Protection Agency (EPA), 2023). Education is central to this goal, as outlined by the United Nations Sustainable Development Goals (SDGs) (Martin, n.d.). The fourth SDG emphasizes equitable access to quality education, including facilities, educators, and a relevant curriculum, while promoting sustainable lifestyles, workforce development, human rights, and environmental awareness. In the Southeastern United States, Alabama faces significant challenges in sustainable development, with high projections of environmental degradation (US EPA, 2016; Carter et al., 2014) and environmental injustices (Engelman-Lado et al., 2019; Pennington, 2016; Sims, 2022; Tinnon, 2010). Alabama currently ranks 45th in the country in sustainable development (Lynch & Sachs, 2021)which is complimented by its 43rd ranking in education (U.S News & World Report, 2023). As Alabama struggles to make adequate progress towards quality education and sustainable development, significant improvements and evaluations of their education system are needed (Lynch & Sachs, n.d.).

The concepts of sustainability are covered, primarily, within the science curriculum (Alabama Learning Exchange, n.d). Alarmingly, less than 38% of Alabama's students have reached science proficiency (SP) since 2016 (Alabama STEM Council, 2022). Regarding workforce development, Alabama hosts large high-school graduation rates (GR) (90.68%) (percentage of students who graduate four years after 9th grade) (Alabama Department of Education, 2022c). Conversely, Alabama ranks lower in college career readiness (CCR) (76.48%) (Alabama Department of Education, 2022c) ranking 47th in the country (U.S News & World Report, 2023), underscoring challenges in post-secondary preparedness. These statistics are alarming considering the understanding of sustainability, SP, and work force development are all necessary in achieving quality education, as well as the remaining SDGs.

Educational equity is a significant issue in Alabama, particularly in rural areas where minority populations face historical and systemic challenges (Anderson, 2016; Lindahl, 2018; Robson et al., 2019). Black and African American students, predominant in rural schools, experience disparities in educational achievement and chronic absenteeism (Alabama Department of Education, 2022c), exacerbated by transportation challenges and isolated school locations (Lindahl, 2018). In 2022, Black and African American students held the lowest rates of CCR, SP and overall academic achievement within the state (Alabama Department of Education, 2022c). Moreover, a study conducted by Mann & Rogers (2021) found that schools in Alabama are considered more segregated now, than ever before. The current segregation of schools, paired with the gap in educational achievement, and school accessibility are of great concern regarding sustainable development; SP, work force development, and an overall understanding of sustainability are critical in mitigating these projected challenges.

The Black Belt is one of the greatest regions of concern within Alabama and the South as it pertains to civil rights, environmental (Holifield, 2023) and educational injustice (Anderson, 2016; Mann & Rogers, 2021). According to Winemiller (2023) the Black Belt region gets its name from its dark rich soil, and formally hosted large concentrations of slave plantations, sharecroppers, and the Civil Rights Movement. The exact boundary of the Black Belt is not well defined and is often debated due to the many variables that define it (Katsinas et al., 2020; Prior & Wong, 2022). Historical injustices have left a long-lasting impact in the general region. Currently, the Black Belt still hosts the largest concentrations of Black and African American populations, rural industries, as well as economic, and social inequalities within the Southeast

(Holifield, 2023). Historical inequities, systemic racism and high poverty rates play a significant role in local school funding, which, in addition to school accessibility, may impact educational achievement (Anderson, 2016). Previous studies have found that rural and Black Belt schools in Alabama have consistently ranked low in academic achievement and argue this may be correlated to lower funding and economic resources (Anderson, 2016; Larkin, 2016; Lindahl, 2018). Moreover, studies conducted by Sohn et al. (2023) state that additional funding helps increase student achievement.

Public school funding in the United States is multifaceted, involving federal, state, and local sources (Alabama Department of Education, 2022a). Local funding, sourced from property taxes, varies widely based on socio-economic status. State funding, distributed through formulas such as Alabama's foundations formula (Alabama Department of Education, 2022a, 2023), aims for equitable resource access. This formula, based on student population, determines funding for essential resources such as staff, salaries, instructional support, and fringe benefits. Additionally, Alabama allocates state funding for "at-risk" student populations, addressing educational needs through programs like tutoring, after-school activities, and free or reduced lunches. The federal government provides funding through grants, such as Title I, which seeks to narrow the achievement gap between economically disadvantaged students and their peers by offering additional resources and support. (United States Department of Education, n.d). This funding supports various initiatives, including hiring staff, implementing educational programs, purchasing materials, offering professional development, providing meals, and more.

Apart from federal, state, and local funding, schools can obtain funds from school revenue and various "other" sources. Local school revenue includes income from events, admissions, concessions, fundraisers, and donations (Alabama Department of Education, 2023). "Other" fund sources, although not clearly defined, can come from entities like the Kellogg Foundation, legal judgments, non-profits and Medicaid reimbursements. Funding in Alabama's school systems are spent through nine entities: instructional services, student support services, instructional staff support, school administrative services, operations and maintenance, transportation, food service, preschool, and general administrative services (Alabama Department of Education, 2022b). Definitions of these expenditures can be found on Table I in Supplemental Materials (Alabama Department of Education, 2023). Funding and expenditures are crucial for student achievement, therefore, when evaluating the equity of Alabama's education system, it is critical to consider all factors including location, funding, demographics, and student achievement.

1.34 Statement of Problem

In summary, Alabama is behind in sustainable development, exacerbated by historical inequalities and challenges within their education system. Quality education is a fundamental objective for substantiable development, as education influences health, workforce development, economic stability, and environmental stewardship. For Alabama to achieve sustainable development goals, it is essential to evaluate the equity of their education system, especially as it pertains to historically underserved areas such as the Black Belt.

1.35 Aim and Hypothesis

Therefore, the aim of this study was to evaluate the relationships and compare the differences of educational achievement (related to sustainable development: SP, CCR, GR), student demographics, chronic absenteeism, funding between and expenditures between Alabama's Black Belt and Non-Black Belt school districts. We hypothesize that the quality and equity of science education in Alabama can be determined through the assessment of these variables.

1.36 Methodology

1.36.1 Defining Black Belt School Districts:

To compare Black Belt and Non-Black Belt school districts, a clear boundary was required to determine which schools were located within it. To do so, the methodology describe in section 4.1 was used.

1.36.2 Data Collection:

Student demographic population (%), funding, Title I classification, expenses, student and teacher population, student achievement and chronic absenteeism from the 2021-2022 fiscal year were collected from 138 public school districts in Alabama using sources and variables listed in section 4.2.

1.36.3 Data Analyses

Data assessments of each variable are described below, full descriptions of statistical tests can be seen in section 4.5.

1.36.4 Demographics and Population

To determine the difference in student racial and ethnic demographics a MANOVA analysis was used. The district type (Black Belt or Non-Black Belt) was set as the fixed factor, and dependent variables were each district's population (%) of students who identified as White, Black, or African American, Asian, Indigenous, and Hispanic and/or Latino. Additionally, an independent samples T-Test was run on each of the variables, as well as total student and teacher population, student/teacher ratio, total minority student population, students with limited English proficiency, students with disabilities, and economically disadvantaged students.

1.36.5 Funding

To determine the difference in in funding a MANOVA analysis was conducted. The district type was set as the fixed factor, and dependent variables were State price per pupil (PPE), Federal PPE, Local PPE, Local School Revenue PPE, and Other PPE. Additionally, an independent samples T-Test was run on each of the variables, as well as total PPE.

1.36.6 Title I classification:

To compare the likelihood of Title I, a Chi-Square analysis was used. District type was inputted as the row(s), and Title I classification was used as the column(s) variables.

1.36.7 Expenditures:

To determine the difference in expenditures a MANOVA analysis was conducted. The district type was set as the fixed factor, and dependent variables were instructional services, student support services, instructional staff support, school administrative services, operations and maintenance services, student transportation, food services, pre-school, and general administrative services. Secondly, an independent samples T-Test was run on each of the variables, as well as total instructional support. Lastly, the mean of each expenditure, by district type, was calculate and represented with a pie chart to compare the difference in funding distribution.

1.36.8 Academic Achievement

To compare student academic achievement, independent samples T-Tests were run with the grouping variable being district type and the testing variables being SP, CCR, and GR.

1.36.9 Chronic Absenteeism

To compare student chronic absenteeism, independent samples T-Tests were run with the grouping variable being district type and the testing variable being chronic absenteeism.

1.36.10Hotspot Maps

Hotspot maps of each variable were developed through ArcGIS, as described in section 4.6.

1.36.11Relationships Between Variables:

Pearson's correlation analyses were performed to further understand funding and expenditure’s relationship with academic achievement. In addition, relationships between academic achievement variables and student demographics were assessed. Chronic absenteeism was also considered in each analysis to explore its correlation with achievement, funding, and demographics.

Backward stepwise-regression analyses were performed on all variables significantly correlated to student achievement, absenteeism, as well as between economically disadvantaged populations and demographics to determine the most significant predictors of achievement.

1.37 Results and Discussion

1.37.1 Demographic and Population Results

Following a MANOVA analysis of funding variables, the results of Box's Test of Equality of Covariance Matrices had a significance value of <.001. Pillai's Trace criterion was then assessed since it is more robust to departures from assumptions. Pillai's trace had a significance value of <.001, indicating a significant difference in demographics between NBBSD and BBSD.

The t-test results of funding variables indicated a significant difference in total student population between BBSD (M =3066.59, SD =4932.00) and NBBSD (M =6020.61, SD =7569.00); t (136) =2.53, p =.014, d =.42 (Figure 2A). This result complements Census statistics, which highlight rural counties as hosting lower population densities (U.S Census, 2020). Additionally, while not statistically significant, NBBSD held higher average populations of teachers (M =376.77, SD =461.00) compared to BBSD (M =207.30, SD =291.48); t (136) =1.88, p =.06, d =.39 (Figure B). Overall, student teacher ratios were not significantly different (t (136) =1.17, p =.42, d =.24), and the average ratio between NBBSD (M =15.72, SD =1.82) and BBSD (M =15.16, SD =3.51) were similar in value (Figure 2C). The indifference in student teacher ratios is most likely due to Alabama's use of the foundations formula (Alabama Department of Education, 2022a, 2023), which determines resources and staff populations based off student enrollment.

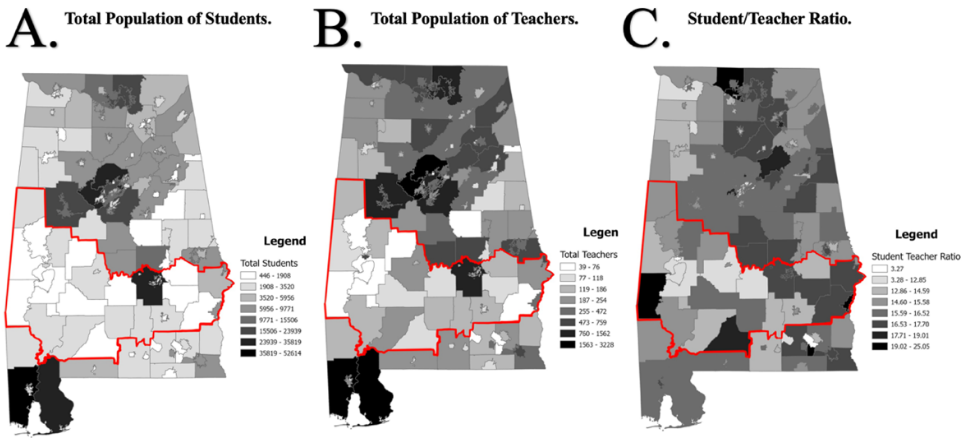

Figure 0-1: Student Teacher Populations and Ratio.

The significant differences observed in the student demographics between Black Belt School Districts (BBSD) and Non-Black Belt School Districts (NBBSD) highlight notable disparities in racial and ethnic compositions. The analysis revealed that NBBSD schools host significantly larger percentages of students who identify as Indigenous ($t(136) = 2.65$, $p = .009$, $d = .38$), two or more races ($t(136) = 3.60$, $p < .001$, $d = .75$), and White ($t(136) = 8.44$, $p < .001$, $d = 1.76$) (Figure 6A and 6B, respectively). Specifically, the mean percentages for Indigenous students ($M_{NBBSD} = 4.80$, $SD_{NBBSD} = 7.92$) and those identifying with two or more races ($M_{NBBSD} = 3.69$, $SD_{NBBSD} = 2.43$) were higher compared to BBSD schools ($M_{BBSD} = 2.00$, $SD_{BBSD} = 3.94$; $M_{BBSD} = 1.94$, $SD_{BBSD} = 1.89$, respectively). It is important to note the small population of both of these groups within the state; Indigenous populations make up .8% of the state while two or more races make up 5.1% (US Census, 2020) With fewer data points, individual variations can have a larger impact on the overall correlation, leading to less reliable and less generalizable results.

The most pronounced difference was in the White student population, where NBBSD schools had a mean percentage of 66.17% ($SD_{NBBSD} = 22.70$) compared to 26.56% ($SD_{BBSD} = 21.58$) in BBSD schools (Figure 6C); $t(136) = 8.44$, ($p < .001$, $d = 1.76$). Conversely, BBSD schools have a significantly larger population of students who identify as Black or African American ($t(136) = 9.86$, $p < .001$, $d = 2.06$), with a mean percentage of 69.44% ($SD_{BBSD} = 20.66$) compared to 24.14% ($SD_{NBBSD} = 22.31$) in NBBSD schools (Figure 6D). This stark contrast between Black and African American student populations compared to White complements the findings of Mann & Rogers, (2021), who state that Alabama's schools are considered more segregated now than ever before. They attribute this to decades long racial oppression, the lack of economic resources in the Black Belt, and the lasting effect of "White Flight" (where White residents moved out of newly integrated towns) following Brown vs. the Board of Education in the 1950s.

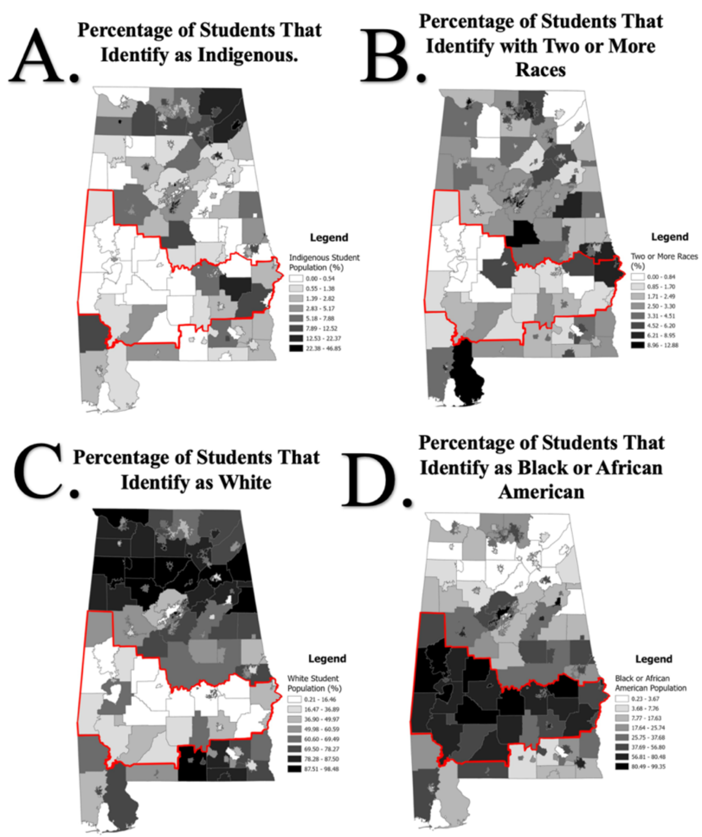

Figure 0-2: Student Populations (%)- Indigenous, Two or More Races, Black or African American and White

There was a significant difference in Hispanic and/or Latino student populations (Figure 3A), with NBBSD hosting larger percentages (M =10.34, SD =10.68) than BBSD (M =4.29, SD =4.65), t(136) =4.52 , p <.001, d =.62. There was no significant difference in Asian student populations (Figure 3B), however NBBSD hosted larger averages (M =1.12, SD =1.68) than BBSD (M =.78, SD =1.23), t(136) =1.01, p =.32, d =.21. Further research is needed to understand why Hispanic and Latino populations are more concentrated outside the Black Belt. However, the small percentages of Hispanic/Latino and Asian students align with the 2020 Census, which shows Alabama's population as 5.3% Hispanic/Latino and 1.5% Asian.

Despite NBBSD hosting higher populations of Hispanic/Latino, Indigenous and students of two or more races, BBSD hosted larger populations of total minority students (M =73.44, SD =21.58), compared to NBBSD (M =33.83, SD =22.70), t(136) =8.44 , p <.001, d =1.76 (Figure 3C). This result further highlights the current isolation of Black and African American students, and the lasting effects of historic policies rooted in racism (Mann & Rogers, 2021).

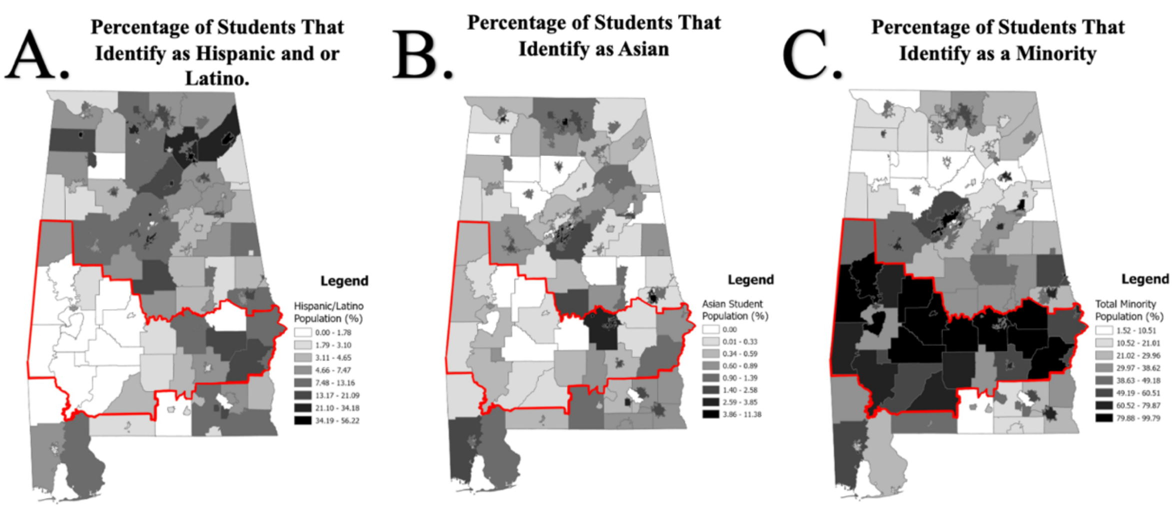

Figure 0-3: Student Demographics (%): Hispanic and/or Latino, Asian and Total Minority Population

There was a significant difference in population of students with limited English proficiency between NBBSD (M=5.21, SD =7.80), and BBSD (M =2.08, SD =2.96); t (136)

=3.37, p =.001, d =.44) (Figure 4A). In 2020 the U.S Census reported less than 6% of Alabamians spoke a language other than English in their homes, which may relate to the overall small population of English language learners. Additionally, there was no significant difference in population of students with disabilities between NBBSD (M=18.03, SD =3.19) and BBSD (M =17.15, SD =3.37); t(136) =1.30, p =.19, d =2.73) (Figure 4B). While previous studies have noted that minorities are often disproportionality diagnosed with learning and behavioral disabilities (Fadus et al., 2020; Shifrer, 2018), these findings may be attributed to Alabama's efforts in addressing the this disproportionality (Alabama Department of Education, 2021).

There was a significant difference in economically disadvantaged student populations, with BBSD hosting larger populations (M =63.58, SD =13.92), than NBBSD (M =47.66, SD =15.37); t(136) =5.05, p <.001, d =1.06) (Figure 4C). These results complement what is known about the lack of economic resources and high poverty rates seen the Black Belt region (Archibald, 2022; Holifield, 2023; S. G. Katsinas et al., 2023)

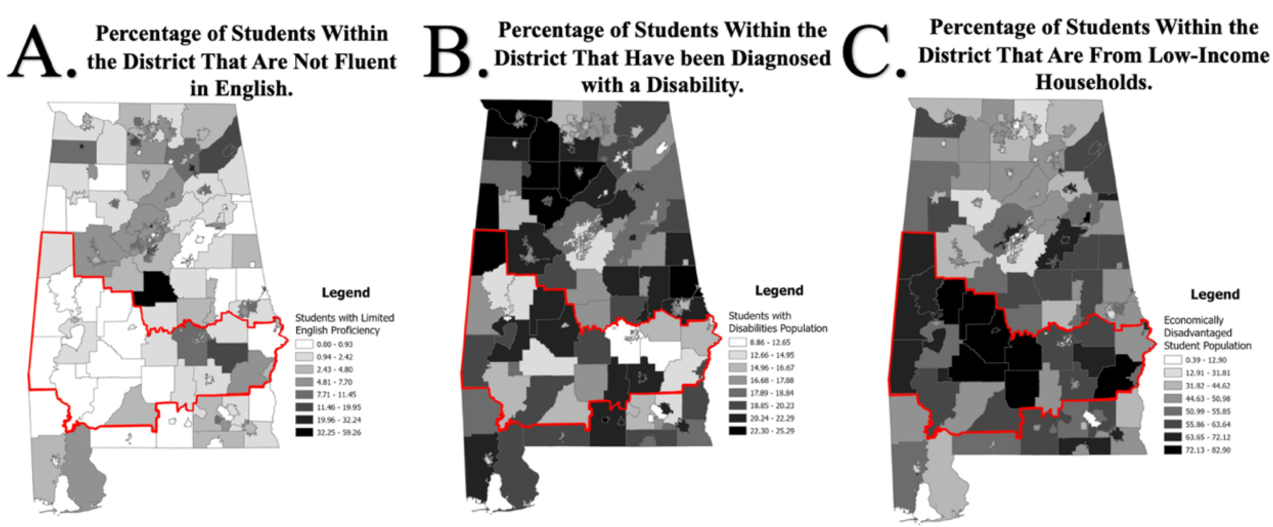

Figure 0-4:Student Demographics (%): Limited English Proficiency, Disabilities and Economically Disadvantaged.

Overall, the results of our demographic analysis indicate a pronounced racial segregation in student populations across the districts. The higher concentration of Black or African

American students in BBSD schools aligns with historical and socioeconomic factors contributing to racial segregation in education (Mann & Rogers, 2021). Furthermore, these disparities underscore the importance of targeted policies and interventions aimed at promoting equity and inclusion in education. Addressing these demographic imbalances is crucial for fostering a more equitable educational landscape and supporting sustainable development within these communities. Future research should explore the underlying causes of these demographic disparities and evaluate the effectiveness of initiatives designed to mitigate their impact.

1.37.2 Funding

Following a MANOVA analysis of funding variables, the results of Box's Test of Equality of Covariance Matrices had a significance value of $<.001$. Pillai's Trace criterion was then assessed since it is more robust to departures from assumptions. Pillai's trace had a significance value of $<.001$, indicating a significant difference in funding between NBBSD and BBSD.

The t-test results of funding variables indicated no significant difference in local funding between NBBSD ($M = 1634.31$, $SD = 1102.69$) and BBSD ($M = 1573.17$, $SD = 1617.89$); $t(136) = .24$, $p = .81$, $d = .05$. This result is surprising in consideration with the higher population of economically disadvantaged students in the area, and this funding source deriving from local taxes. However, Alabama hosts the lowest property value per capita in the country (Fritts, 2021), to which Anderson (2016) states that the structure of Alabama's tax distribution system is what allows for this lack of difference and financial support in school systems. Local funding amongst districts is visualized in Figure 5A.

While no differences were found amongst local sources, there were significant difference observed in state funding ($t(136) = 4.54$, $p < .001$, $d = 1.35$) and federal funding ($t(136) = 4.42$, p

<.001, d =1.33). BBSD averaged higher state ($M_{StatePPE}$ =8317.28, $SD_{StatePPE}$ =1014.63) and federal funding PPE ($M_{FederalPPE}$ =4277.55, $SD_{FederalPPE}$ =2154.28), compared to NBBSD ($M_{StatePPE}$ =7432.59, $SD_{StatePPE}$ =525.93, $M_{FederalPPE}$ = 2451.42, $SD_{FederalPPE}$ =1078.96). These findings are to no surprise, considering the additional grants the state and federal government provide to schools with increased populations of economically and educationally "at risk" students (United States Department of Education, n.d;Alabama Department of Education, 2022a, 2023). However, these results may challenge claims that Alabama's funding formula is inequitable (Larkin, 2016) and underserves rural and/or Black Belt communities (Anderson, 2016; Lindahl, 2018). State and federal funding amongst districts is visualized in Figure 5B and C, respectively.

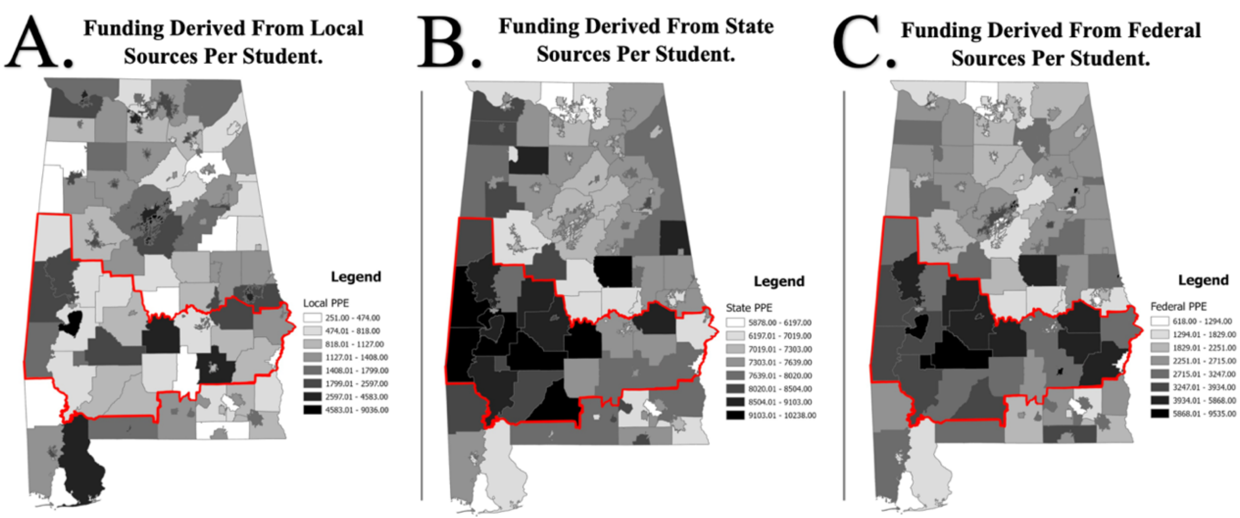

Figure 0-5: Funding: Local, State, Federal PPE.

There was no significant difference observed in other funding between NBBSD (M =45.89, SD =70.98) and BBSD (M =61.52, SD =83.98); t(136) =1.01, p =.31, d =.21. However, there were significant difference observed in local school revenue (t(136) =2.73 ,p =.007, d =.57) and total funding (t(136) =3.77, p <.001, d =1.11). BBSD averaged less local school revenue (M =200.03, SD =107.78) and more total funding (M =13495.03, SD =2423.40), compared to

NBBSD ($M_{LocalSchoolRevenue}$ =324.24, $SD_{LocalSchoolRevenue}$ =238.37, $M_{TotalPPE}$ =11733.95, $SD_{TotalPPE}$ =1287.23). Local school revenue can be generated from extracurricular activities and fundraisers, to which studies have found that students and parents of lower socioeconomic status are less likely to participate in, compared to higher-income students (Cheung et al., 2008; Eime et al., 2015; National Center for Education Statistics, 1995). These results are visualized in Figure 6.

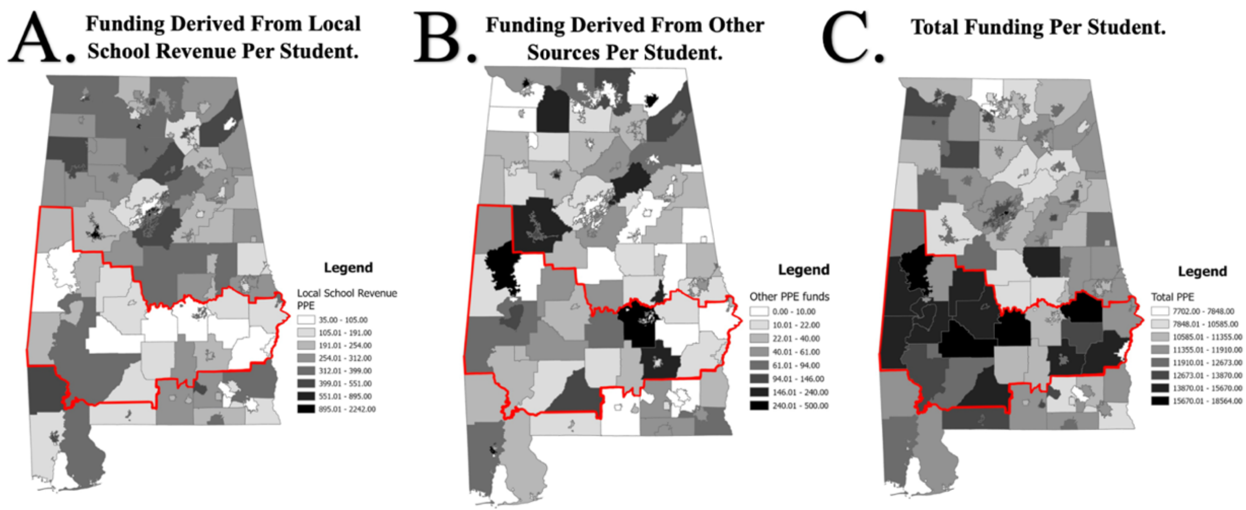

Figure 0-6: Funding: Local School Revenue, Other Sources, and Total PPE.

1.37.3 Title I classification

A chi-square test of independence showed that there was a significant association between Title I classification and district type, X^2 (degrees of freedom =136, sample size =138) =8.37 (chi-square statistic value), p =.004, phi value =.25 (strong). In summary, 72.41% of BBSD are Title I, compared to 42.20% of NBBSD. Title I classification by district type is represented in Figure 7. These disparities stem from BBSD serving larger populations of economically disadvantaged students, requiring more support to address achievement gaps.

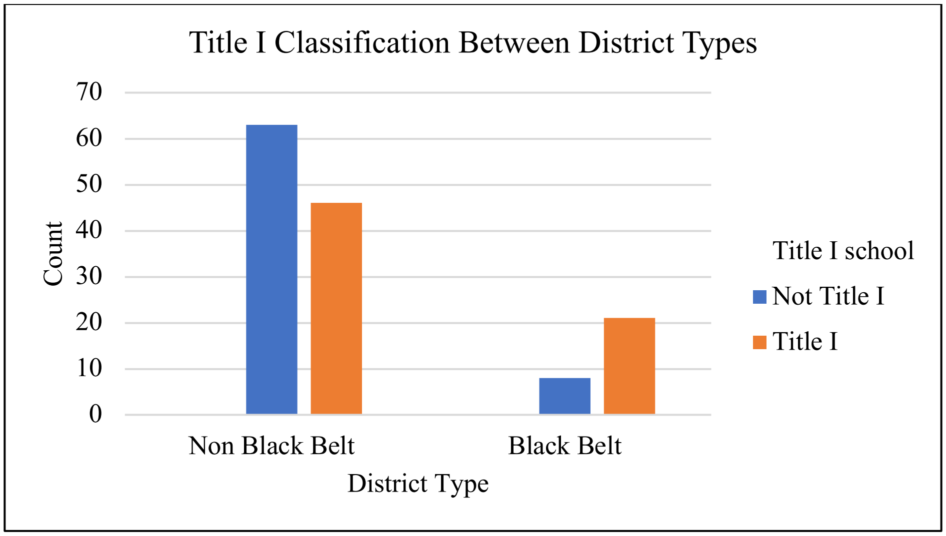

Figure 0-7: Title I Classification Between District Types

1.37.4 Expenditures

Following a MANOVA analysis of funding variables, the results of Box's Test of Equality of Covariance Matrices had a significance value of <.001. Pillai's Trace criterion was then assessed since it is more robust to departures from assumptions. Pillai's trace had a significance value of <.001, indicating a significant difference in expenses between NBBSD and BBSD.

The t-test results of expenditure variables indicated significant differences between student support services (t(136) =3.23, p =.003, d =.97), instructional staff support (t(136) =2.63,p =.007, d =.78) and total amount spend on instructional services (t(136) =4.62, p <.001, d =1.39). On average, BBSD spent more on each of these variables ($M_{\text{Student Support}}$ =1074.17, $SD_{\text{Student Support}}$ = 435.54, $M_{\text{Instructional Staff}}$ =657.86, $SD_{\text{Instructional Staff}}$ =395.51, $M_{\text{Total Istructional Support}}$ =9306.48, $SD_{\text{Total Istructional Support}}$ =1087.31), compared to NBBSD ($M_{\text{Student Support}}$ = 804.74, $SD_{\text{Student Support}}$ = 217.45, $M_{\text{Instructional Staff}}$ = 458.04, $SD_{\text{Instructional Staff}}$ = 203.71, $M_{\text{Total Istructional Support}}$ = 8368.30, $SD_{\text{Total Istructional Support}}$= 941.12). There were no significant differences observed in school administrative services (M_{NBBSD} =658.30, SD_{NBBSD} =107.45, M_{BBSD} =868.52, SD_{BBSD} =687.05);

t(136) =1.64, p =.11, d =.65). Moreover, were no significant differences observed in instructional services (M_{NBBSD} =6447.22, SD_{NBBSD} =737.05, M_{BBSD} =6705.93, SD_{BBSD} =693.63); t(136) =1.70, p =.09, d =.36).

The differences found amongst student support, staff support, and total instructional services are largely due to state grants, which seek to address educational needs through programs like tutoring, after-school activities (Alabama Department of Education, 2022a, 2023). To this end, the lack of difference in the singular "instructional services" variable is surprising, however it may not be considered an additional program, nor school administrative services, in comparison to after-school services (student support) and professional development (instructional services). These results are visualized in Figure 8.

Figure 0-8: Expenditures: Instructional Support Services.

There was no significant difference in preschool services between BBSD (M =260.97, SD =105.47) and NBBSD (M = 230.04, SD = 129.99); $t(136)$ =1.18, p =.24, d =.25 (Figure 9A). This expense is directly related to the population of students with disabilities, which also resulted in an insignificant difference.

A significant difference food services ($t(136)$ =3.58, p <.001, d =.75) (Figure 9B), and general administrative services ($t(136)$ =3.92,p <.001, d =1.13) (Figure 9C) were observed. On average, BBSD spent more each of these variables ($M_{\text{Gerneral Administrative}}$ =972.17, $SD_{\text{Genreal Administrative}}$ =453.61, $M_{\text{Food Service}}$ =991.45, $SD_{\text{Food Service}}$ =248.79) compared to NBBSD ($M_{\text{Gerneral Administrative}}$ =628.88, $SD_{\text{Genreal Administrative}}$ =249.59, $M_{\text{Food Service}}$ =840.73, $SD_{\text{Food Service}}$ =187.36). Further research is needed to understand the difference found amongst general administrative services, however the increased expenses observed amongst food services are most likely related to the higher likely hood of Title I classification, which seeks to prove educational and meal support to economically disadvantaged student populations (United States Department of Education, n.d), which are highest amongst the Black Belt.

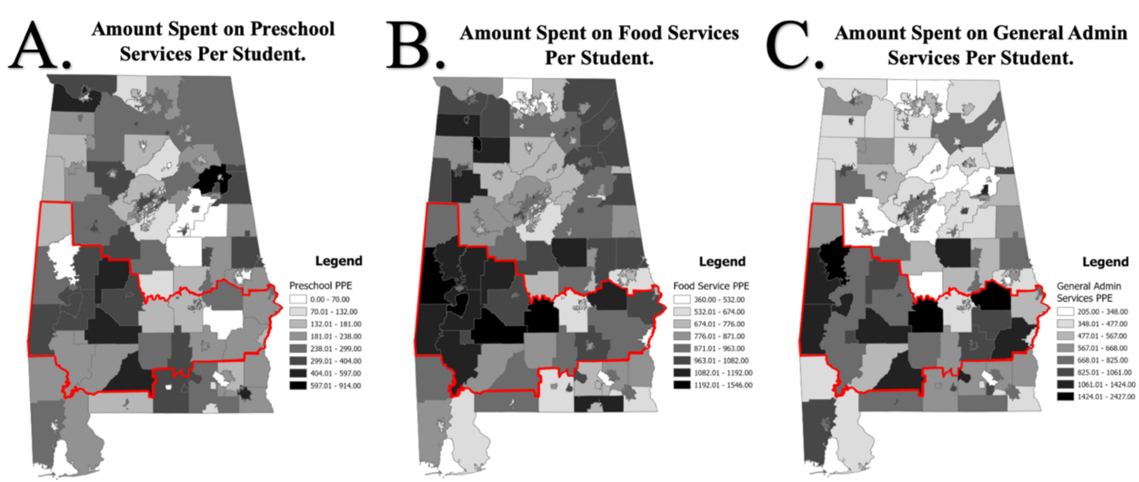

Figure 0-9: Expenditures: Preschool, Food Services and General Administrative Services

There was no significant difference in operation and maintenance expenses (Figure 10A) between BBSD (M =1305.66, SD =486.04) and NBBSD (M =1132.73, SD =302.66); $t(136)$

=1.82, p =.08, d =.50. Further work is needed to understand this lack of discrepancy, as well as a comparison of school facilities amongst these two regions. Especially considering the results of a 2006 study, where rural Southern teachers reported working in outdated, poor quality facilities (McCoy, 2006).

A significant difference in transportation expenses was observed (t(136) =3.35, p =.002, d =.96) with BBSD spending more (M =829.90, SD =451.23) than NBBSD (M =538.08, SD =251.68 (Figure 10B). The difference in transportation expenses complement the findings of Lindahl (2018), and are mostly likely due to rural schools hosting more isolated school locations due to their smaller population densities; thus increasing the length of travel to transport students to school.

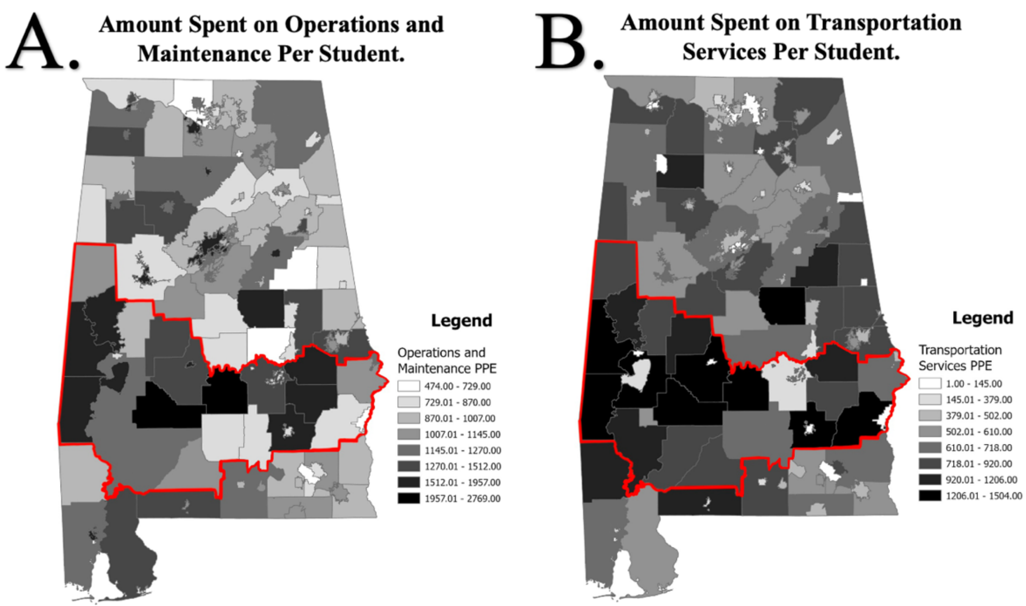

Figure 0-10: Expenditures: Operations and Maintenance, and Transportation.

A summary of the total of each expenditure by district type, indicate that BBSD spend 2% more on general administrative services, and transportation services, as well as 1% more on instructional staff support and student support services. Moreover, BBSD allocate 55% of their funds towards instructional services while NBBSD allocate 49%. The overall differences in expenditures between district types are most likely related to differences in funding, with BBSD receiving more funding through grants to address challenges in academic achievement and students in need. The summary allocations of each expenditure, by district type, can be seen in Figure 11.

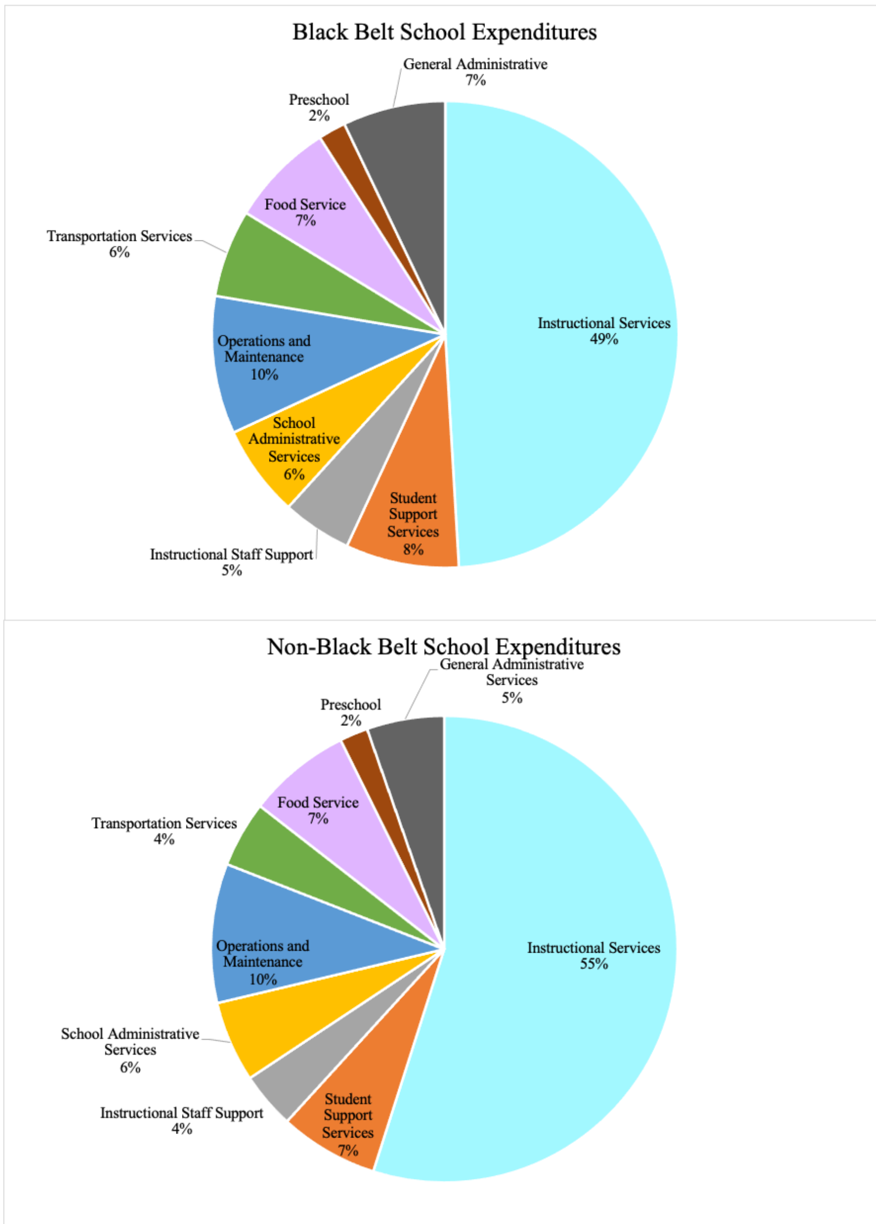

Figure 0-11: Expenditures by District Type

1.37.5 Academic Achievement

A significant difference in SP (Figure 12A) was observed between BBSD (M =20.85, SD =11.17) and NBBSD (M =37.92, SD =13.65); t(136) =6.20, p <.001, d =1.30. Additionally, there was a significant difference in GR between BBSD (M =87.29, SD =8.82) and NBBSD (M =91.50, SD =5.52); t(136) =2.44, p =.02, d =.66 (Figure 12B). Moreover, there was a significant difference in CCR between BBSD (M =64.73, SD =16.69) and NBBSD (M =78.47, SD =13.98); t(136) =4.51, p <.001, d = .94 (Figure 12C). Overall, NBBSD hosted higher populations in each of these categories compared to BBSD.

According to Rothstein (2015) these results are directly related to the social and economic disadvantage found within the Black Belt. Rothstein states that student achievement is directly related to poverty, as well as the lack of diversity and representation in school systems. Moreover, this study suggests that concentrating students with these disadvantages in racially and economically homogeneous schools further hinders their academic achievement; thus, stressing the imperativeness for Alabama to addresses school district, and county racial and economic segregation.

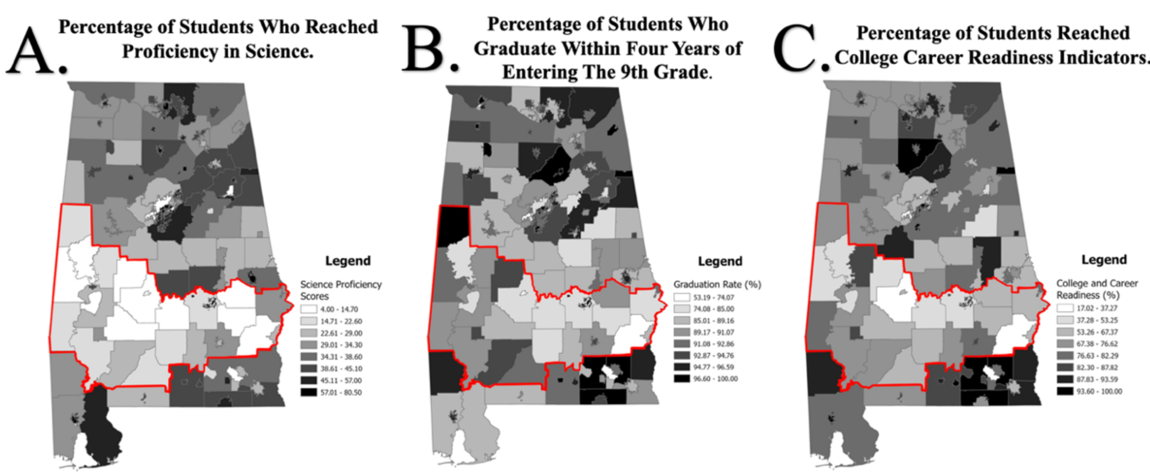

Figure 0-12: Student Achievement

1.37.6 Chronic Absenteeism

A significant difference in chronic absenteeism observed between the district types ($t(136) = 2.37$, $p = .02$, $d = .62$). With BBSD hosting higher percentages of chronically absent students ($M = 20.93$, $SD = 9.23$) compared to NBBSD ($M = 16.63$, $SD = 6.17$), as represented in Figure 13. Increased absence in the Black Belt region may relate to transportation challenges and isolated school districts (Lindahl, 2018). To address absenteeism previous studies have found that parental involvement plays an integral role in attendance (Mitchell, 2021; Sheldon & Epstein, 2004; U.S Council of Economic Advisers, 2023). Additionally, Grooms & Bohorquez (2022) who studied chronic absenteeism amongst rural LatinX students found that lack of representation and cultural competencies in schools has attributed to student isolation and negative perceptions of school. To address this issue Grooms & Bohorquez (2022) advocate for the diversification of schools and the implementation of culturally relevant and responsive strategies.

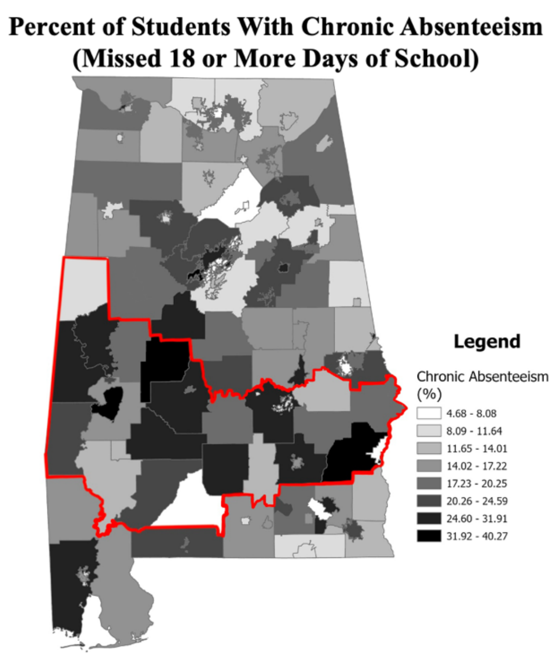

Figure 0-13: Chronic Absenteeism

1.37.7 Correlation Results

Figure 14 represents the Pearson’s correlation results between funding sources, academic achievement, and chronic absenteeism. SP had negative associations with state funds ($r = -.55$, $p < .001$), federal funds ($r = -.51$, $p < .001$), and total funds ($r = -.36$, $p < .001$). Positive associations were observed local funds ($r = .28$, $p < .001$) and local school revenue ($r = .47$, $p < .001$). Significant relationships were not observed between SP and other funds ($r = .01$, $p = .95$).

CCR had negative relationships with state funds ($r = -.34$, $p < .001$), federal funds ($r = -.43$, $p < .001$), total funds ($r = -.34$, $p < .001$), and positive with local school revenue ($r = .37$, $p < .001$). Significant relationships were not observed between CCR local funds ($r = .04$, $p = .65$) and other funds ($r = .05$, $p = .60$).

GR had a negative association with state PPE ($r = -.20$, $p = .02$), federal PPE ($r = -.38$, $p < .001$), total PPE ($r = -.27$, $p = .001$), and positive with local school revenue PPE ($r = .30$, $p < .001$). Significant relationship between GR and local PPE ($r = .01$, $p = .96$) or other funds ($r = .02$, $p = .82$) were not observed. Chronic absenteeism had positive relationships with state funds ($r = .31$, $p < .001$), federal funds ($r = .42$, $p < .001$), total funds ($r = .36$, $p < .001$), and negative with local school revenue PPE ($r = -.33$, $p < .001$. A significant relationship was not observed between chronic absenteeism, local PPE ($r = .02$, $p = .82$) or other funds ($r = .05$, $p = .55$).

The increased performance in academic achievement and decrease in chronic absenteeism in relation to local school revenue may relate to increased parental support and involvement (McKenzie, 2022; Mitchell, 2021; Sheldon & Epstein, 2004; U.S Council of Economic Advisers, 2023). However, the general trend of negative relationships between funds and student achievement challenge the findings of many researchers, including a study by the Massachusetts Institute of Technology, which found that increased funding correlates to higher test scores (Sohn et al., 2023), especially if spent on historically underperforming districts. It's important to acknowledge that the results of this study are based on one fiscal year of data; a longitudinal study would provide a more comprehensive understanding of how monetary support impacts academic achievement growth. However, while the results of this study challenge the belief that funding improved academic achievement, other studies have report that smaller test score gaps can be achieved by increasing diversity and representation in schools (Grimshaw, 2016; Rothstein, 2015; United States Department of Education, 2023)

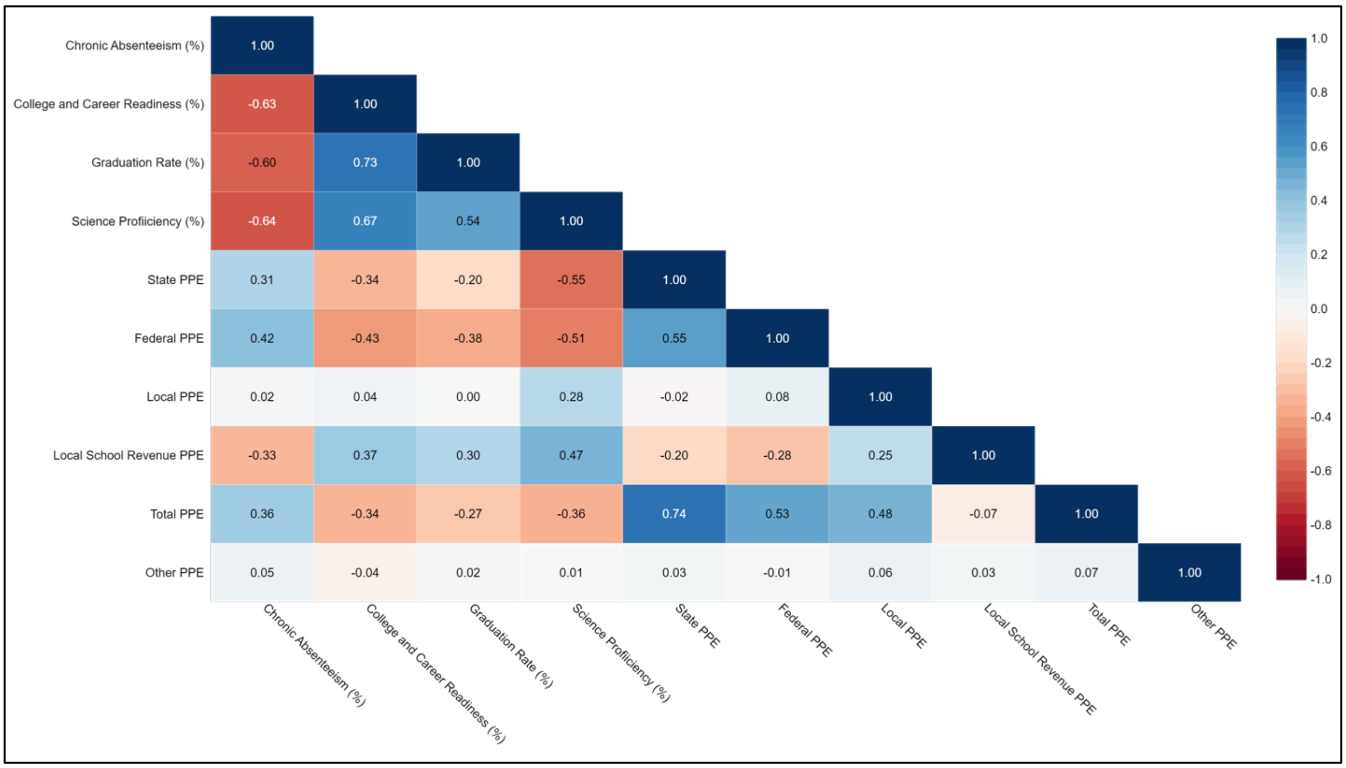

Figure 0-14: Correlations Between Funding, Academic Achievement, and Chronic Absenteeism. The relationship value, "r", can be found within each box; negative relationships are represented in red, while positive are indicated by blue.

Figure 15 represents the Pearson's correlation results between expenditures, academic achievement, and chronic absenteeism. Significant negative correlations were observed between SP and student support services (r =-28, p <.001), instructional staff support (r =-.35, p <.001), operations and maintenance (r =-.20, p =.02), transportation services (r =-.42, p <.001), preschool

($r = -.28$, $p < .001$), food services ($r = -.53$, $p < .001$) and general administrative services ($r = -.51$, $p < .001$). A significant relationship was not observed between SP and instructional services ($r = .14$, $p = .12$), nor total instructional support ($r = -.11$, $p = .19$).

Significant negative correlations were observed with CCR and student support services ($r = -.32$, $p < .001$), instructional staff support ($r = -.32$, $p < .001$), school administrative services ($r = -.19$, $p = .03$), total instructional support ($r = -.23$, $p = .01$), operations and maintenance ($r = -.18$, $p = .04$), transportation services ($r = -.32$, $p < .001$), food services ($r = -.37$, $p < .001$) and general administrative services ($r = -.40$, $p < .001$). Significant relationships were not observed between CCR and instructional services ($r = .01$, $p = .95$), or preschool ($r = -.10$, $p = .26$).

Significant negative correlations were observed with GR and student support services ($r = -.20$, $p = .02$), instructional staff support ($r = -.29$, $p < .001$), total instructional support ($r = -.21$, $p = .01$), transportation services ($r = -.20$, $p = .03$), food services ($r = -.19$, $p = .02$) and general administrative services ($r = -.33$, $p < .001$). Significant relationships were not observed between GR and instructional services ($r = -.05$, $p = .55$), school administrative services ($r = -.12$, $p = .15$), operations and maintenance ($r = -.13$, $p = .13$), and preschool ($r = -.03$, $p = .70$).

Lastly, significant positive relationships were observed between chronic absenteeism and student support services ($r = .34$, $p < .001$), instructional staff support ($r = .25$, $p = .003$), operations and maintenance ($r = .28$, $p < .001$), transportation ($r = .27$, $p = .001$), food services ($r = .40$, $p < .001$), preschool ($r = .21$, $p < .001$), and general administrative services ($r = .38$, $p = .012$). Significant relationships were not observed between chronic absenteeism and instructional services ($r = -.01$, $p = .89$), school administrative services ($r = -.04$, $p = .62$) and total instructional support ($r = .14$, $p = .11$).

Again, while these finds challenge previous work (Sohn et al., 2023) by reporting negative relationships with increased expenses and academic achievement and positive with chronic absenteeism, this study is limited by only evaluating one year of data. However, these findings may further promote the need of integrating additional strategies including promoting parental involvement, cultural competence and diversity.

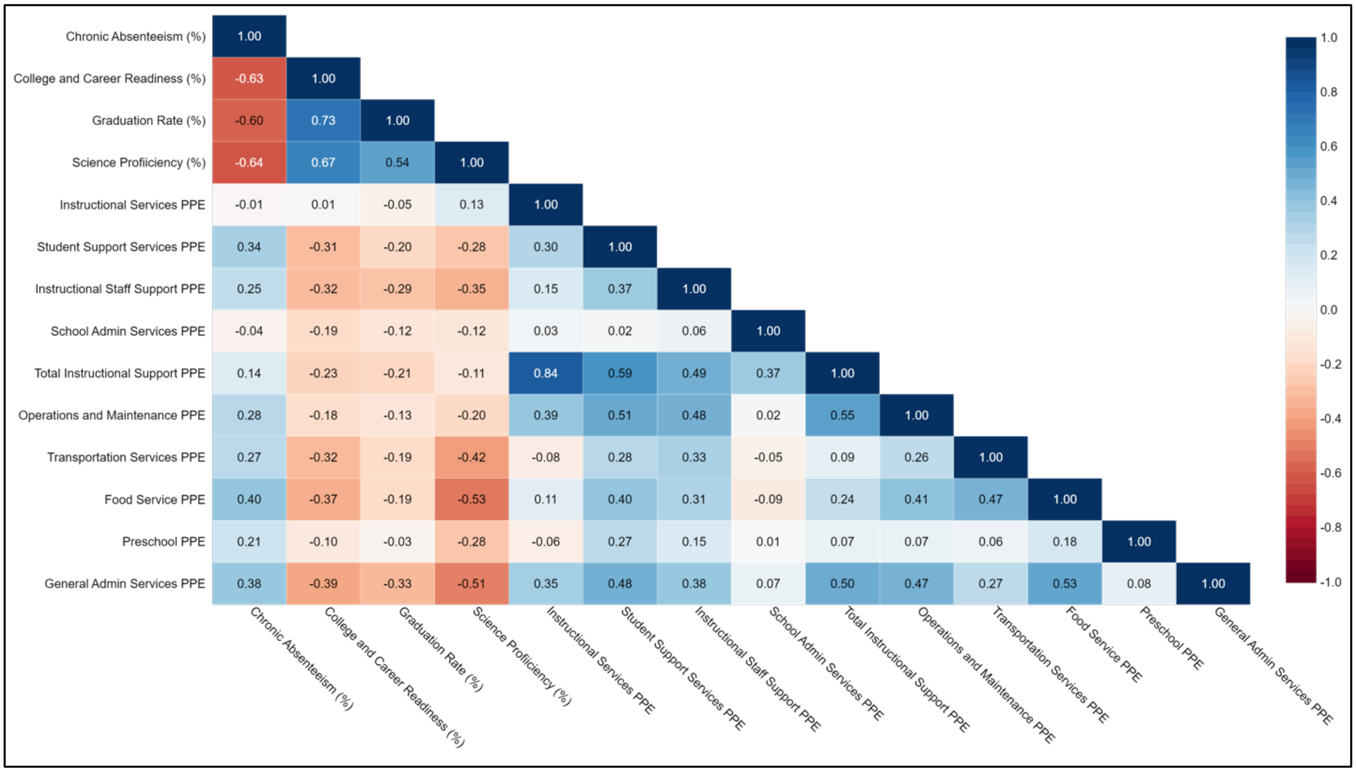

Figure 0-15: Correlations Between Expenditures, Academic Achievement, and Chronic Absenteeism.

The relationship value, “r”, can be found within each box; negative relationships are represented in red, while positive are indicated by blue.

Figure 16 represents the results of a Pearson correlation test between student achievement variables and chronic absenteeism. The results indicate that schools with higher SP populations are more likely to have higher rates of CCR ($r = .67$, $p < .001$), and GR ($r = .54$, $p < .001$), and lower rates of chronic absenteeism ($r = -.64$, $p = < .001$). There is also a positive relationship between CCR and GR ($r = .73$, $p < .001$), and negative relationships between chronic absenteeism with CCR ($r = -.63$, $p < .001$), and GR ($r = -.60$, $p < .001$).

The positive correlations found amongst SP, CCR, and GR are not surprising considering student achievement is the metric used to calculate these variables (Alabama Department of Education, 2022c; Alabama STEM Council, 2022; Dailey, 2019). However, it can be argued that science achievement can correlate to overall academic achievement and career readiness. Previous work has attributed science education to increasing performance by promoting creativity, critical reasoning, research and questioning, cooperation and problem solving (Kazu & Kurtoglu Yalcin, 2021). Additionally, it is important to acknowledge the current the significance of science education within the job market. According to Boggs et al. (2022) there is a workforce shortage among scientific fields and there is a significant need to develop talent to fill these positions and promote economic growth. Moreover, promoting interdisciplinary science education and proficiency can enhance sustainable development, especially amongst rural students (Gavari et al., 2022).

Furthermore, the relationship found between absenteeism and academic achievement complements the report published by the White House's Council of Economic Advisers (2023), which found that absence from school resulted in lower test scores. Overall, these finding underscore the significance of science proficiency and attendance in fostering academic achievement and post-secondary readiness.

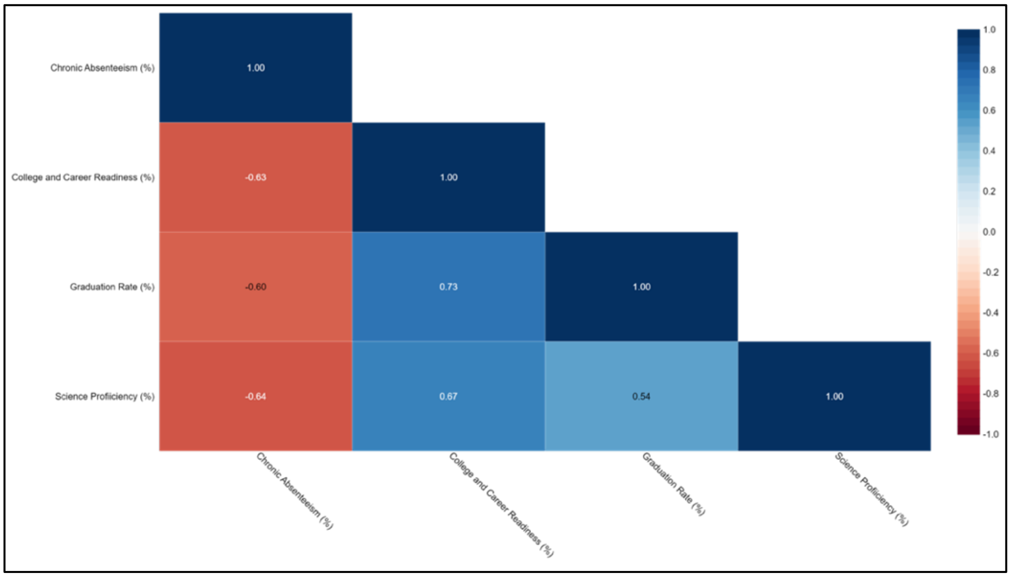

Figure 0-16: Correlations between Science Proficiency Scores, College Career Readiness, Graduation Rate and Chronic Absenteeism.
The relationship value, "r", can be found within each box; negative relationships are represented in red, while positive are indicated by blue.

Figure 17 represent the correlations between academic achievement, chronic absenteeism and demographics. SP was higher amongst schools with larger populations of White (r =.73, p <.001), two or more races (r =.27, p =.001), and Asian students (r =.51, p <.001), and lower amongst larger populations of Black and African Americans (r =-.74, p <.001), economically disadvantaged (r =-.84, p <.001), and overall minorities (r =-.73, p <.001). There were no significant correlations between SP with students with disabilities (r =-.16, p =.06), limited English proficiency (r =-.07, p =.42), indigenous (r =-.07, p =.39) or Hispanic and/or Latino students (r =.01, p =.89).

Similarly, CCR had positive relationships with White (r =.66, p <.001) and Asian (r =.20, p =.02) student population, and negative relationships with Black and African American (r =-.64, p <.001), economically disadvantaged (r =-54, p <.001), and overall minority (r =.64, p <.001) populations. There were no significant correlations between CCR and students with disabilities (r

$= .02$, $p = .82$), limited English proficiency ($r = -.13$, $p = .14$), indigenous ($r = -.02$, $p = .81$), two or more races ($r = .07$, $p = .45$), and Hispanic and Latino students ($r = -.002$, $p = .99$).

Positive relationships were observed between GR and White ($r = .51$, $p < .001$) and Asian ($r = .20$, $p = .02$) student populations. Conversely, negative relationships were observed with GR and Black and African American ($r = -.48$, $p < .001$), economically disadvantaged ($r = -.43$, $p < .001$), and overall minority ($r = -.51$, $p < .001$) populations. There were no significant correlations between GR and students with disabilities ($r = .05$, $p = .58$), limited English proficiency ($r = -.10$, $p = .27$), indigenous ($r = -.06$, $p = .53$), two or more races ($r = .004$, $p = .96$), and Hispanic and Latino students ($r = -.03$, $p = .75$).

Lastly, chronic absenteeism had negative relationships with White ($r = -.55$, $p < .001$) and Asian ($r = -.31$, $p < .001$) student populations, and positive relationships with Black and African American ($r = .56$, $p < .001$), economically disadvantaged ($r = .59$, $p < .001$), and overall minority ($r = .55$, $p < .001$) populations. There were not significant relationships observed between chronic absenteeism and students with disabilities ($r = .07$, $p = .40$), limited English proficiency ($r = -.002$, $p = .98$), indigenous ($r = -.05$, $p = .57$), two or more races ($r = -.09$, $p = .27$), and Hispanic and Latino students ($r = -.06$, $p = .50$).

The gap of achievement amongst racial and ethnic groups complement previous findings (Assari et al., 2021; Ayoub et al., 2009; Rothstein, 2015) as well as the previous correlations observed amongst the Black Belt. Overall, it is clear that the lack of school diversity and economic opportunity in minority dense regions plays a significant role in academic achievement. To this end, outside of achievement it is important to note the correlations found amongst demographics and economically disadvantaged student populations. Previous research has found that socioeconomics has a direct relationship with student achievement. Cooper &

Stewart (2021) found that household income has a positive causal effect on student cognitive and social-behavioral development. Our correlation results find that Black and African American student populations have a significant positive correlation with economically disadvantaged populations (r=.63, p<.001) and negative correlations with White (r=-.59, p<.001), two or more races (r=-.25, p=.003), and Asian (r=-.53, p<.001) student populations. These correlations relate the lack of economic opportunity that has been developed due to historical inequities. It is well known that the "white flight" movement has negatively impacted economic opportunity within the Black Belt region, which has had long term effects overtime (Hardy et al., 2018).

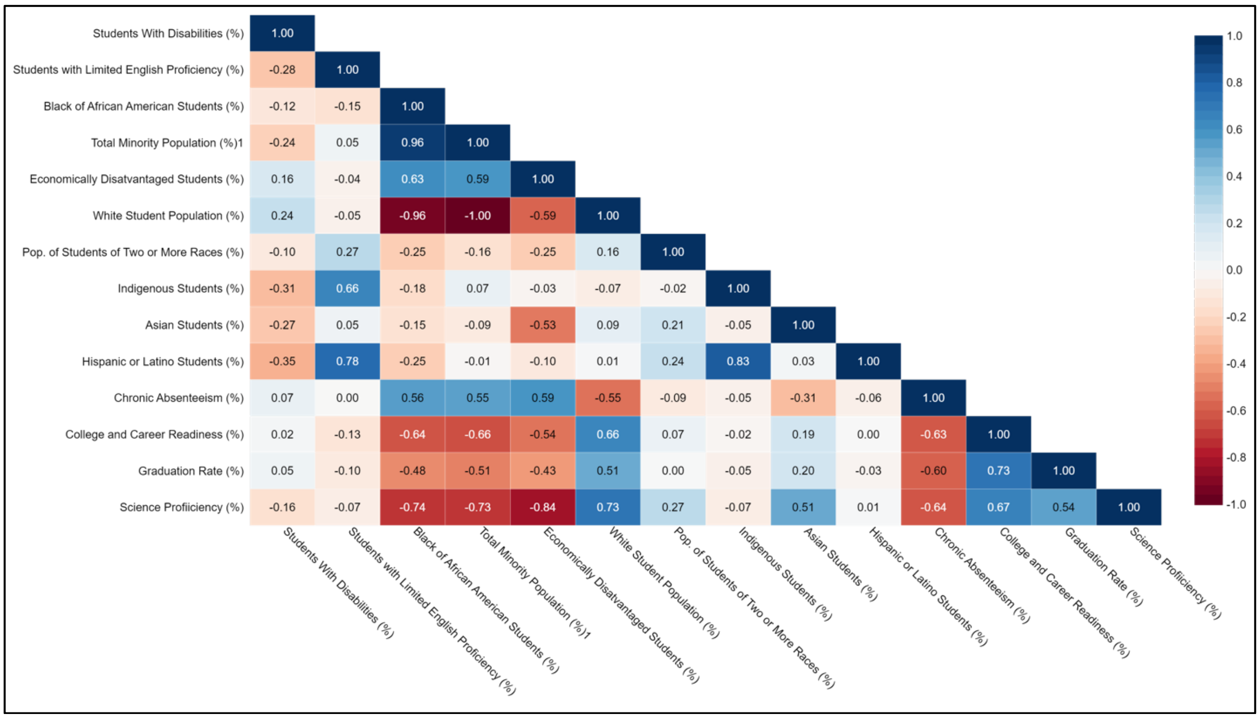

Figure 0-17: Correlations Between Academic Achievement, Chronic Absenteeism and Demographics.

The relationship value, "r", can be found within each box; negative relationships are represented in red, while positive are indicated by blue.

1.37.8 Regression Results

Firstly, a backward stepwise regression was calculated to predict SP populations between each significantly correlated variable. The final model, entered with local PPE, transportation services, economically disadvantage student populations, White student populations, Asian student populations and CCR, exhibited a high degree of predictability for science proficiency; F (3,131) = 144.82, $p<.001$, $R^2 = .86$. The standard coefficients indicated that local PPE(b=.13, t=3.70, $p <.001$), White student populations (b=.41, t=8.35, $p<.001$), Asian student populations (b=.22, t=5.57, $p<.001$), and CCR (b=.15, t=3.29, p=.001) were significant positive predictors. While transportation services (b=-.09, t=-2.60, p=.010) and economically disadvantaged student populations (b=-.34, t=-6.30, $p<.001$) were significant negative predictors.

These results highlight the significance of socio-economic and student achievement, with economically disadvantaged student populations being significant negative indicators. Additionally, Asian and White student populations were positive indicators, these demographics were significantly negatively correlated with economically disadvantaged student populations. A backward regression analysis, conducted on demographics to predict economically disadvantaged student populations (F(2,135) = 94.48, $p<.001$, $R^2=.58$), found that Asian (b=-.44, t= -7.90, $p<.001$) and Black and African American student populations (b=.56, t=9.93, $p<.001$) were the most significant predictors, with Asian populations being negative indicators. Furthermore, Local PPE was a significant positive indicator for SP, and areas with higher income are likely to have higher property taxes, thus, larger local PPE allocations. These results complement the findings of Cooper & Stewart (2021) who stated that socio-economics impact student cognitive and social-behavioral development. Furthermore our results complementthe regression and correlation results of Hung et al. (2019) which found that school expendures did not play significant roles in student achievment, however household income was a significant contibutor to achievement gaps, especially amongst White and Black students in the South.

Transportation services were another significant negative predictor in this model. As stated previously, rural schools often have larger commute times and expenses, of which our t-test results found that this is consentrated in the Black Belt. These results are further supported by previous research which has found that larger distances to school negatively impact student achievment (Barrett et al., 2019). Lastly, CCR was a a positive predictor, which may be due to this varibale being measured by overall academic achievement and science education being related to

To predict GR between a backward regression was calculated with each significantly correlated variable. The final model, entered with food services, chronic absenteeism and CCR exhibited a high degree of predictability; F (3,134)= 63.07, p <.001, R^2=.58. The standard coefficients indicated that food services (b=.136, t=2.22, p=.03) and CCR (b=.619, t=8.55, p<.001) were positive indicators, while chronic absenteeism was negative (b=-.26, t=-3.59, p<.001). Increased food services derive from federal (Title I) and state grants (to schools with higher populations of economically and educationally at-risk students), research has found that food insecurity negatively impacts cognitive function (Royer et al., 2021), and that providing meal assistance helps increase academic achievement (Ruffini, 2022; Schwartz & Rothbart, 2019). CCR was another positive indicator, measured through holistic student achievement; students who are thriving academically are more likely to receive the credits necessary for graduation. Chronic absenteeism was the most significant negative predictor in this model, which again complements statements from the White House's Council of Economic Advisers (2023), which stated that absence from school resulted in lower achievement scores.

To predict CCR a backward regression was calculated between each significantly correlated variable. The final model, entered with school administrative services, operations and maintenance, transportation services, food services, White student populations, chronic absenteeism and GR exhibited the highest degree of predictability; $F(7, 130) = 43.99$, $p < .001$, $R^2 = .69$. Positive indicators included operations and maintenance (b=.12, t=2.18, p=.03), White student populations (b=.31, t=4.87, p<.001), and GR (b=.44, t=7.00, p<.001). Negative indicators included school administrative services (b=-.11, t=-2.26, p=.03), transportation services (b=-.10, t=-1.90, p=.06), food services (b-.12, t=-1.93, p=.06) and chronic absenteeism (b=-.16, t=-2.33, p=.02).

The positive prediction found with operations and maintenance expenses complement research that has found that enhanced infrastructure benefits learning and educational success (Barrett et al., 2019). The positive prediction found with White student populations may again underscore the significance of socioeconomics (Cooper & Stewart, 2021) and the impact of "white flight" (Hardy et al., 2018), with White populations being negatively correlated to economically disadvantaged student populations (r=-.59, p<.001). Additionally, CCR being a positive predictor of GR is unsurprising since overall student achievement (used to calculate CCR) is critical for student graduation.

Transportation services and chronic absenteeism were negative predictors in this model as well, further highlighting the importance of attendance (U.S Council of Economic Advisers, 2023) and school accessibility (Barrett et al., 2019). Food services results in this model may be surprising given evidence that meal support increases student achievement (Ruffini, 2022; Schwartz & Rothbart, 2019) and compared to the regression results of GR, however, these increased funds in food services are provided by additional grants to serve schools with large economically disadvantaged student populations, and as mentioned previously, socioeconomics have shown to directly relate to student achievement (Cooper & Stewart, 2021). More work is needed to understand this difference in prediction with food services between these two models as well as why school administrative services were a significant negative predictor for GR.

Lastly, a backward regression was calculated to predict chronic absenteeism between each significantly correlated variable. The final model, entered with state funds, student support services, operations and maintenance, economically disadvantaged student populations, CCR and GR, revealed the highest degree of predictability; $F(6,131)=27.41$, $p<.001$, $R^2=.54$. Positive indicators included student support services ($b=.14$, $t=1.88$, $p=.06$), operations and maintenance ($b=.14$, $t=2.05$, $p=.04$), and economically disadvantaged student populations ($b=.39$, $t=5.00$, $p<.001$). Negative indicators included state funds ($b=-.15$, $t=-1.78$, $p=.08$), CCR ($b=-.20$, $t=-2.14$, $p=.04$) and GR ($b=-.26$, $t=3.02$, $p=.003$). These results find that student support services, operations and maintenance and economically disadvantaged student populations do not predict better attendance, again highlighting the role of socioeconomics and the need for better support systems other than funding to eliminate achievement gaps (Hung et al., 2019). Additionally, the negative predictors found amongst CCR and GR, highlight the significance of attendance and achievement (U.S Council of Economic Advisers, 2023).

Overall, the results of these regression analyses collectively illustrate the multifaceted nature of educational achievement and the critical influence of socio-economic factors, necessitating a holistic approach to educational policy and resource allocation. School funding and expenditure alone is not enough to eliminate achievement gaps, diversity, school locality and socioeconomics also play significant roles.

1.38 Conclusion

The analysis of demographic, funding, expenditure, and academic achievement variables between Black Belt School Districts (BBSD) and Non-Black Belt School Districts (NBBSD) in Alabama highlights significant disparities that underscore the ongoing challenges and inequities within the state's educational system.

Demographic analyses indicate pronounced racial segregation, with BBSD hosting significantly higher populations of Black or African American students and lower percentages of White students compared to NBBSD. This segregation aligns with historical and socioeconomic factors contributing to racial isolation and educational disparities, reinforcing the findings of Mann & Rogers (2021). The higher populations of economically disadvantaged and minority students in BBSD further accentuate these demographic imbalances, necessitating targeted interventions to promote equity and inclusion.

Funding disparities were evident, with BBSD receiving significantly more state and federal funding compared to NBBSD, likely due to the higher numbers of economically disadvantaged students. However, local funding did not differ significantly between the districts, which is surprising given the socioeconomic disparities. This anomaly may be attributed to Alabama's tax distribution system, which limits the financial support available to schools in economically disadvantaged areas. The additional state and federal funds received by BBSD are essential for addressing the educational needs of at-risk students, yet the overall funding still challenges claims of equitable distribution within the state (Larkin, 2016).

BBSD allocated more resources towards student support, instructional staff support, and total instructional services, reflecting the additional needs of their student populations. Significant differences were observed in general administration and food services expenditures, with BBSD spending more in these areas, possibly due to higher Title I classifications and associated support programs. These expenditure patterns are indicative of efforts to address educational disparities, though further research is needed to understand the differences in general administration costs.

Academic performance metrics revealed that NBBSD outperformed BBSD in terms of standardized test scores, graduation rates, and college and career readiness. These differences are likely linked to the socioeconomic disadvantages prevalent in the Black Belt, as well as the concentration of racially and economically homogeneous student populations in BBSD. Chronic absenteeism rates were higher in BBSD, possibly due to transportation challenges and less parental involvement, further hindering academic achievement.

Correlational analysis showed that increased local school revenue positively associated with academic achievement and lower absenteeism, highlighting the importance of community and parental support. Conversely, the general trend of negative relationships between state and federal funds with student performance suggests that mere financial inputs may not suffice without addressing underlying socioeconomic and demographic challenges.

Regression analyses reveal that socio-economic factors, demographics, and school resources significantly influence student outcomes. Local PPE, White and Asian student populations, and CCR are significant positive predictors of science proficiency, while transportation services and economically disadvantaged populations negatively impact it. This underscores the complex interplay between economic conditions and student performance, supporting the findings of Cooper & Stewart (2021) on socio-economic impacts on student development. Additionally, food services and CCR positively predict graduation rates, while chronic absenteeism remains a significant negative predictor, aligning with research on the detrimental effects of absenteeism on achievement (White House's Council of Economic Advisers, 2023). Predictors of CCR include operations and maintenance, White student populations, and graduation rates, with negative predictors being school administrative services, transportation, food services, and chronic absenteeism, highlighting infrastructure's role in educational success (Barrett et al., 2019). Finally, predicting chronic absenteeism reveals the importance of support services and operations in maintaining attendance, further emphasizing the need for targeted support to address socio-economic disparities (Hung et al., 2019). These findings collectively illustrate the multifaceted nature of educational achievement and the critical influence of socio-economic factors, necessitating a holistic approach to educational policy and resource allocation.

Overall, these findings emphasize the need for comprehensive, targeted policies to address the deep-rooted disparities in Alabama's educational system. Efforts should focus on promoting racial and economic integration, enhancing community and parental involvement, and ensuring equitable distribution of resources. Future research should delve into the root causes of these disparities and evaluate the effectiveness of existing and proposed interventions aimed at fostering a more equitable educational landscape. In conclusion, addressing the educational inequities between BBSD and NBBSD is crucial for supporting sustainable development and providing all students with equal opportunities to succeed. Collaborative efforts among policymakers, educators, and communities are essential to bridge these gaps and create a more inclusive and effective educational system in Alabama.

1.39 Supplemental Material

Table D: Definitions of Expense Categories

Expenditure	Definition
Instructional Services:	Instructional Services encompass all forms of teacher-student interactions across various settings, including traditional classrooms, field trips, homes, hospitals, and co-curricular activities like field trips and sports. This function also includes teaching through technology such as TV and computers, and supports roles like classroom assistants and substitutes, alongside the procurement, maintenance, and repair of instructional furniture and equipment.
Student Support Services:	Student Support Services encompass a comprehensive array of activities dedicated to fostering the holistic development and well-being of students within educational settings. These services span various domains, including attendance monitoring, counseling and guidance, testing, health care provision, social services, work study programs, psychological assessment and intervention, instructional technology support, speech pathology and audiology services, and miscellaneous support functions not covered by specific categories. They aim to address diverse student needs, promote academic success, enhance social-emotional skills, and ensure equitable access to educational opportunities for all learners.
Instructional Staff Support:	Instructional staff support comprises a range of services aimed at enhancing the effectiveness and professional growth of educators within the educational system. These services encompass activities such as curriculum development and enhancement, providing resources and materials to support teaching and learning, facilitating staff development through workshops and in-service training, overseeing educational media resources including libraries and technology integration, and addressing any additional needs of instructional staff that may not fit into the aforementioned categories. The overarching goal is to empower educators with the tools, knowledge, and support necessary to deliver high-quality instruction and facilitate student learning effectively.
School Administrative Services:	School Administrative Services encompass a variety of functions dedicated to the efficient and effective management of educational institutions. This category includes activities such as directing and overseeing the operations of a school or instructional center, including the roles of school principals and assistant principals. It also covers the general operation of the school administrator's office, including administrative support functions. Additionally, any other administrative activities specific to the management of a school or instructional center that do not fit into the aforementioned categories fall under this designation. The aim is to ensure smooth and organized administrative processes that support the overall mission and goals of the educational institution.
Total Instructional Support:	Overall, instructional support serves include any services or activities that provide supervision and/or technical and logistical support to facilitate or enhance instruction. To this "total instructional support" includes student support services, instructional staff support, educational media, and local school administration (school administrative services).

Operation & Maintenance Services	Operation & Maintenance Services encompass a broad spectrum of activities dedicated to ensuring the functionality, safety, and cleanliness of the physical infrastructure within educational facilities. These services focus on maintaining a conducive environment for teaching and learning by keeping the grounds, buildings, and major equipment in optimal working condition and good repair. The sub-services provided within this expense include security, building upkeep, grounds keeping, custodial service, information and technological services, and school vehicle maintenance.
Student Transportation:	Services Student Transportation Services encompass activities dedicated to safely conveying students to and from schools, including transportation administrative services focused on managing transportation operations, regular transportation for daily student commutes, special education transportation for students with specialized needs, and various other services such as transportation monitoring and vehicle maintenance. These services ensure the safe and efficient transportation of students, supporting their access to educational opportunities and extracurricular activities while promoting their overall well-being.
Food Services	Food Services encompass activities dedicated to providing food to students and staff within a school system, including the preparation, delivery, and serving of regular meals, lunches, or snacks. This service area also includes the acquisition of equipment and related items for the child nutrition program. Maintenance and repairs associated with food service fall within the Operation & Maintenance Service expenditures, designated specifically for food service programs. Additionally, Other Food Services cover miscellaneous food service activities that do not fit into the aforementioned categories.
Pre-school	In 1991, through Act No. 1991-474, pre-school funding was established to provide special education services for children with disabilities. To determine the appropriate funds each school system reports how many children, age 3-4, that have special needs. This total number is then divided into the total appropriation, and the money is allocated by multiplying this number by the number of children in the system. The dollars allocated to each school district must be used to provide free, appropriate public education for all eligible children with disabilities.
General Administrative Services:	General Administrative Services encompass activities dedicated to establishing and administering policies for the operation of the school system. This includes Board of Education Services focused on policy establishment and oversight, Executive Administrative Services involving general administration by the superintendent and assistance in executive responsibilities, and Business Support Services covering fiscal operations such as budgeting, accounting, and purchasing services. These services ensure the effective governance, management, and financial stability of the school system to support its mission and goals.

Note: Definitions of school expense categories derived from the Alabama Department of Education Accounting Manual and State Allocation Calculations Manuals (Alabama Department of Education, 2022, 2023).

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Greening Alabama's Classrooms: The Impact of Active Lessons on Biomaterials for Water Remediation

1.41 Abstract

Alabama's robust forest products industry presents significant potential for sustainable development through innovative bio-based material solutions, such as water remediation technologies addressing emerging contaminants. However, the state faces notable challenges, ranking 45th in sustainable development and 43rd in education. Enhancing education, especially aligned with the United Nations Sustainable Development Goals, is critical for fostering environmental stewardship and economic resilience. Currently, only 37% of Alabama students are proficient in science, and the state has been rated poorly for climate education. Disparities in educational equity, particularly among rural minority students in the Black Belt region, further compound these challenges. This study explores the integration of lessons on forest products and bio-based water remediation within Alabama's secondary science curricula to improve environmental awareness and sustainable development. Employing problem-based active learning and relevant teaching strategies, the study aims to enhance science proficiency and inspire interest in environmental careers. Preliminary results indicate significant improvements in students' environmental awareness and understanding of sustainable practices. This approach not only addresses educational deficiencies but also leverages Alabama's natural resources, promoting a sustainable and equitable future for the state.

Keywords: Sustainability, Forest Products, Water Remediation, Science Proficiency, Equitable Education.

1.42 Introduction and Background

Alabama's potential for sustainable development is vast, particularly with its robust forest products industry. This industry offers opportunities to develop innovative bio-based materials solutions, including water remediation technologies aimed at addressing emerging contaminants (Gizaw et al., 2021). However, the state faces significant challenges, evident in its 45th ranking in sustainable development and 43rd in education (Lynch & Sachs, 2021; U.S News & World Report, 2023). Education emerges as a critical tool in navigating these challenges, empowering individuals with the knowledge and skills to promote sustainable development. Quality education, aligned with the United Nations Sustainable Development Goals, is pivotal for fostering environmental stewardship, economic resilience, and social equity (Martin, n.d.). By investing in education and leveraging its forest products industry, Alabama can promote its potential for sustainable growth while addressing pressing environmental and social concerns, paving the way for a more prosperous and equitable future.

Concepts of sustainability are primarily covered within the science curriculum (Alabama Learning Exchange, n.d), in which only 37% of students in Alabama have reached proficiency (Alabama STEM Council, 2022). In 2020, Alabama was one of six states in the U.S to receive an "F" (failure) in effectively teaching the causes and consequences of a changing climate according to the National Center for Science Education (National Center for Science Education, 2020). Within this review, researchers state that the biggest failures within Alabama's curriculum include the downplaying of human behavior (as a cause of climate change), not assessing the risks and immediacy of the issue, and not promoting critical thinking or responsible participation in civic deliberation.

Along with struggles associated with curriculum and proficiency, Alabama faces significant challenges in achieving educational equity, particularly evident in the disparities present amongst rural minority students, who are predominantly located within the Black Belt region (Lindahl, 2018; Mann & Rogers, 2021; Robson et al., 2019). The Black Belt, a historic region known for its dark rich soil, and legacy of slavery and the civil rights movement (Winemiller, 2023), hosts the largest population of economically at risk and Black and African American students within the state (Holifield, 2023). Alarmingly, on average, Alabama's Black and African American students host the lowest rates of science proficiency (Alabama STEM Council, 2022), academic achievement, and college career readiness (Alabama Department of Education, 2022). These indexes are critical to achieve sustainable development, which is of great concern considering the heightened rates of environmental challenges and inequities predicted for minority populations and the Black Belt (Carter et al., 2014; Holifield, 2023).

To address the challenge of science proficiency, equity, and sustainable development in Alabama it is critical to enhance curriculum, while considering all populations within the state. Two effective strategies that have been studied include problem-based-active learning and relevant teaching. Relevant teaching involves subjects and materials that relate to learners' lives, emotions, or interests (Willis, 2007). A psychological study by Willis (2007) found that students are more likely to remember and become interested in the material when it relates to their personal lives and emotions. Moreover, the same study found that stress and anxiety increase when the learning material is irrelevant to students. When the research team assessed the brain's functionality under stress, they found that the area responsible for higher cognitive memory, consolidation, and storage was substantially inhibited. When students learn material that connects to their lives and interests, stress was significantly absent, and the areas of the brain that promote focus and memory were activated. Therefore, when relevant teaching is applied, students experience a higher chance of learning and retention.

Problem-based active learning involves students solving real-world challenges through hands-on learning experiences (Akınoğlu & Tandoğan, 2007; Kontra et al., 2015). In this teaching method, the students are responsible for developing a solution to a presented problem; they develop and assess their predictions through hands-on activities. Hands-on activities stimulate motor-related areas of the brain, and when practiced, studies have shown that active-learning correlates to higher test scores in students (Kontra et al., 2015). Moreover, problem-based active learning stimulates critical thinking, communication, and time management skills (Akınoğlu & Tandoğan, 2007). Problem-based active learning is an effective teaching strategy that increases students' academic success and skill sets.

The integration of lessons on forest products, particularly focusing on bio-based water remediation for the treatment of eutrophication, within secondary science curricula proposes not only a problem-based relevant topic, but also complement several state curriculum standards, and promotes workforce development. To begin, Alabama has over 23 million acres of forest land, comprising around 70% of the state (Randle, 2020); therefor, most students in Alabama have been exposed to forests and/or forest bio-based product industries. Moreover, the Black Belt, hosts the largest density of woodlands, furthering making the material inclusively relevant (Andrew J. Hartsell, 2015; Cartographic Research Lab Department of Geography University of Alabama, 2007). The exploration of bio-based water remediation methodologies underscores the imperativeness of sustainable solutions. Water is an essential resource for survival and well-being. With this, water quality is a relevant subject for all students, especially within the state of Alabama. Alabama is highly susceptible to fertilizer, wastewater and stormwater pollution which can develop eutrophic conditions in aquatic environment (Gurung et al., 2013; Mirhosseini & Srivastava, 2016). The nitrates and phosphates that cause eutrophication cannot be treated by traditional oxidation-treatment methods due to their fully oxidized state, however they can be remediated through the sorption capabilities of bio-based materials (Gizaw et al., 2021).

Moreover, these concepts meet state curriculum standards (Alabama Learning Exchange, n.d): **a)** Engage in argument from evidence to evaluate how biological or physical changes within ecosystems (e.g., ecological succession, seasonal flooding, volcanic eruptions) affect the number and types of organisms, and that changing conditions may result in a new or altered ecosystem. **b)** Develop and use models to trace the flow of water, nitrogen, and phosphorus through the hydrosphere, atmosphere, geosphere, and biosphere. **c)** Design solutions for the protection of natural water resources (e.g., bioassessment, methods of water treatment and conservation) considering properties, uses, and pollutants (e.g., eutrophication, industrial effluents, agricultural runoffs, point, and nonpoint pollution resources). To this end, a lesson centered around eutrophication and bio-based water treatment methods has the potential to cultivate a learning experience that serves towards sustainable development.

Additionally, exposure to the potential of the forest product industry and bio-based water remediation engenders awareness of career opportunities in environmental science, forestry, and sustainable engineering. By showcasing the practical applications of scientific knowledge in environmental conservation, students are inspired to consider vocations in scientific fields pertinent to sustainability. This, in turn, cultivates a workforce poised to engage in innovative solutions to environmental challenges.

1.43 Objective and Hypothesis

In conclusion, the incorporation of a lesson on forest products, specifically bio-based water remediation for eutrophication treatment, within high school curricula serves as a strategic intervention to bolster environmental consciousness and foster sustainable workforce development. Therefore, the objective of this study was to instill an understanding of environmental issues, by promoting sustainable methodologies, facilitating interdisciplinary learning, and catalyzing career exploration. By developing this lesson, we hypothesize that this educational initiative will nurture environmentally aware and motivated citizens of the future.

1.44 Methodology

1.44.1 Lesson Development

During Summer 2021, secondary science teachers from the Auburn, Alabama area were recruited via email to aid in the development of a lesson plan that centered around biobased material water remediation. In Summer 2022, two teachers met with the research team to discuss lesson scaffolding and lesson materials to ensure that the lesson could be practically used in a high school setting. Following the feedback from teachers, the research team developed a lesson plan aimed to center around a blended framework of the 5-E instructional model (Rodger W. Bybee, 2015) and tasked-based learning (Zhou et al., 2013) which is described in Chapter 4.

1.44.2 Survey Development

Following lesson development, pre and post surveys were created to measure the relevance, equity, and impact of the lesson on increasing environmental awareness, understanding of sustainable concepts, and post-secondary interest in the field. The pre-lesson survey was developed to for teachers to participate in before lesson implementation. The questions, listed below, include school geographic location, subject and level taught, concerns of academic resources, belief in relevant learning, ten questions regarding student understanding and concern of sustainable concepts covered within the lesson and their environmental awareness.

Pre-Lesson Questions:

Q1: What is your name? [open response]

Q2: What school and district do you teach at? [open response]

Q3: How would you best describe the area you are in?

a. Rural
b. Urban
c. Suburban

Q4: Answer the following according to your student's attitudes towards these questions: [Likert scale: 0-strongly disagree, 1-somewhat disagree, 2- neither agree nor disagree, 3-somewhat agree, 4-strongly agree]

a) Students have an awareness and concern for the environment.
b) Students feel that climate change is a real GLOBAL concern.
c) Students feel that climate change is a real concern for the state of Alabama.
d) Students feel that pollution is a real concern for the state of Alabama.
e) Students feel that pollution is a real GLOBAL concern.
f) Students feel that water insecurity is a real issue in Alabama.
g) Students feel that water insecurity is a real GLOBAL issue.
h) Students are familiar with water remediation/filtration methods.
i) Students are familiar with plant-based solutions for environmental issues.

j) Students can communicate sustainable ways to remediate contaminated water systems.

Q5: Do you believe that having relevant, relatable content on environmental concerns will increase environmental awareness in your students? [Likert scale: 0- definitely not, disagree, 1- probably not, 2- might or might not, 3- probably yes, 4- definitely yes]

Q6: Do you have concerns about academic resource availability and accessibility in your area? (i.e., access to electronics, lab equipment, free educational experiences) [Likert scale: 0- definitely not, disagree, 1-probably not, 2- might or might not, 3- probably yes, 4- definitely yes]

The post-lesson survey was developed for teachers to participate in after the implementation and student evaluation. This survey included the same identifying questions (Q1, Q2) and student questions (Q4). In addition, questions regarding the number of students taught, how many time the lesson was repeated (how many classes taught), the subject of the class, the lesson's relevance, equity, and ability to spark academic and career interests were asked (listed below). To evaluate the validity of the surveys a question on the surveys' accuracy in measuring student environmental awareness and understanding was included in the post-lesson survey for three random participants.

Additional Post-Lesson Questions:

1. Select what grade your students are in (multiple answers are allowed):
    a. 6th
    b. 7th
    c. 8th
    d. 9th
    e. 10th

f. 11th

g. 12th

2. How many individual classes did you use this lesson for? [open response]
3. What subject and level were this lesson used in? [open response]
4. About how many students in total participated in this lesson? [open response]
5. Do you implement formative assessments within your curriculum throughout the school year?
    a. Yes
    b. No
    c. Might or might not
6. Do you implement summative assessments within your curriculum throughout the school year?
    a. Yes
    b. No
    c. Might or might not
7. Do you believe that this unit provided relevant, relatable content on environmental concerns and solutions? [Likert scale 0-strongly disagree, 1-somewhat disagree, 2-neither agree nor disagree, 3-somewhat agree, 4-strongly agree]
8. If you disagree, how can we improve the relevancy and relatability of this unit? [open response]
9. Do you believe this unit provided equitable academic resources to teach this unit? (all participants were able to learn, interact and engage in materials regardless of personal backgrounds)

a. Yes

b. No

10. If you disagree, how might we improve the equitability of resources for the unit? [open response]

11. Overall, do you believe that implementing this unit improved environmental awareness among students? [Likert scale 0-strongly disagree, 1-somewhat disagree, 2- neither agree nor disagree, 3-somewhat agree, 4-strongly agree]

12. Do you believe that this lesson has the potential to spark interest in environmental careers and studies for your students? [Likert scale 0-strongly disagree, 1-somewhat disagree, 2- neither agree nor disagree, 3-somewhat agree, 4-strongly agree]

13. Do you feel our surveys (when compared pre vs post) ask questions that measures whether this lesson impacted students understanding of sustainability, environmental awareness, and science proficiency?

    a. Yes

    b. No

Both pre- and post-lesson surveys were approved by the Auburn University Instructional Review Board (#22-416 EX 2211) prior to implementation and were evaluated by a third party for validity and reliability, as mentioned in section 4.3.

1.44.3 Black Belt Boundary

In consideration to the inequities present within the Black Belt, a clear boundary of the region was needed to further evaluate and compare the results of lessons served within this area. To do so, the boundary methodologies described in section 4.1 were used.

1.44.4 Lesson Pilot

Following the development of the lesson plan and surveys, the lesson was piloted in local classrooms during the 2022-2023 school year to evaluate the practicality of the resources and materials.

1.44.5 Teacher Recruitment and Lesson Implementation

Following the lesson pilots, a teacher training workshop was held, in partnership with Alabama Science in Motion, in June 2023 at Auburn University. Teachers who participated in the workshop were trained on how to perform the lesson and use the lab; following the workshop teachers were recruited to participate in the study and sign up to use the lesson. Following the completion of the workshop, a sign-up calendar was sent to all who participated, and the lesson was delivered to the school.

1.44.6 Evaluation of Survey Results

Sample populations were evaluated through descriptive statistics. Additionally, the results of Q4 from the pre and post surveys were compared in a paired samples t-test; this included the difference in overall average as well as comparisons of each individual question. Likert-scale questions (Q4) that were used to assess student attitudes and awareness for the environment and sustainability concerns were evaluated using Cronbach's Alpha (α) was used to evaluate internal constancy. Comparisons between the average pre- lesson, average post lesson, differences in pre-post results, concerns for academic resources, relevance of the lesson, improvement in environmental awareness, and career interests between Black Belt and Non-Black Belt schools were evaluated using an independent samples t-test analysis. The same variables were compared between geographic regions using a one-way ANOVA analysis. The relationship between geographic region and Black Belt/Non-Black Belt schools were evaluated using a Chi Square analysis. Full descriptions of statistical tests can be seen in section 4.5.

1.45 Results and Discussion

1.45.1 Lesson Plan

A six task, 5-E lesson plan was developed (Figure 1), beginning with Task 1 (engagement), where students began the lesson with a conversation about their use and security of water, followed by a short video of algal blooms in the United States. Task 1(explore) finished off with students exploring the phenomena of eutrophication through a reading activity and questions. The activity included information about nitrate and phosphate cycles, fertilizer, eutrophication's relationship with climate change and human behavior, the process of oxidation for traditional water treatment, what bio-based treatment is, and the potential of Alabama's forest products industry to develop alternative sustainable bio-based. Following the reading, students engaged in a discussion about the reading activity questions. In Task 2 students watched a short video on different water quality testing methods, which they will perform later during the lab activity.

In Task 3 (explore), students began the preliminary steps of the hands-on lab activity to which they will create and test their own bio-based filter. Students formed groups of 3-5 and received a materials catalog, a diagram of a filter in which they will sketch their design, and a series of questions to guide their reading and preparation. The manual featured additional information on water quality treatment, testing, and provided a list of bio-based materials they can choose to use for their filter design. The materials offered included pulp (donated from a paper mill), cotton-balls, sodium alginate, activated carbon, as well as sand. Students received a budget for their design, challenging their critical thinking by limiting the total amount of materials they could use for their design.

Following the design of their filter, students moved on to Task 4, testing their design. Students began the activity by assembling their filters and received a pre-measured sample of fertilizer (to which they mixed with 250ml of water). Filters were made from a recycled water bottle. The bottom of the water bottle was cut to allow students to layer their materials inside (according to their design), the cap was drilled with holes to allow the sample to pass through into an empty beaker, a cotton ball was placed inside the cap to prevent any loose materials from passing through the filter. Students tested the concentrations of nitrates and phosphates of the sample using hand-held colorimeters. Following their initial readings, students passed the sample through their filters and measured the concentrations of the sample after filtration. After collecting their data, students recorded the materials used and pre-post concentration results from their classmates designs to use for comparison.

After all data were collected students moved to Task 5 where they evaluated and explained their results and answered questions related to real world applications. Application questions included ways to mitigate agricultural pollution, a proposal on how to locate the point source of pollution, and ways to potentially treat a contaminated system. To wrap up the lesson, Task 6 elaborated on the potential to use algae as a bio-based solution for eutrophication and water remediation. Student’s understanding and achievement was evaluated through their responses to the reading and lab activities.

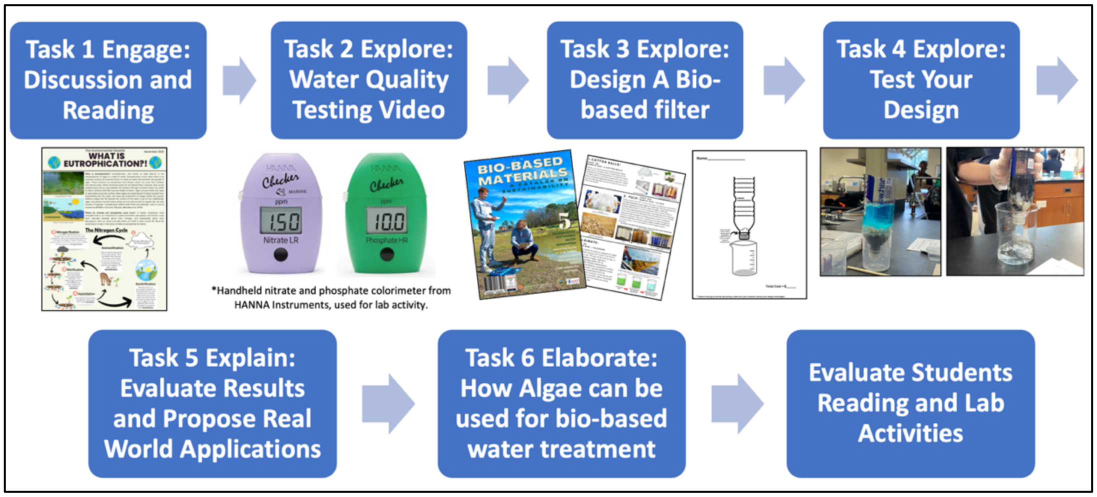

Figure 0-1: Visualization of Lesson Plan

1.45.2 Black Belt Boundary

School districts located within the Black Belt region can be seen in section 4.1.

1.45.3 Sample population

Eighteen teachers attended the workshop, overall, 13 teachers signed up for the lesson and participated in the study (including the first two pilot teachers). In total the lesson was taught 46 times, serving 958 students in grades 9-12 (Figure 2)

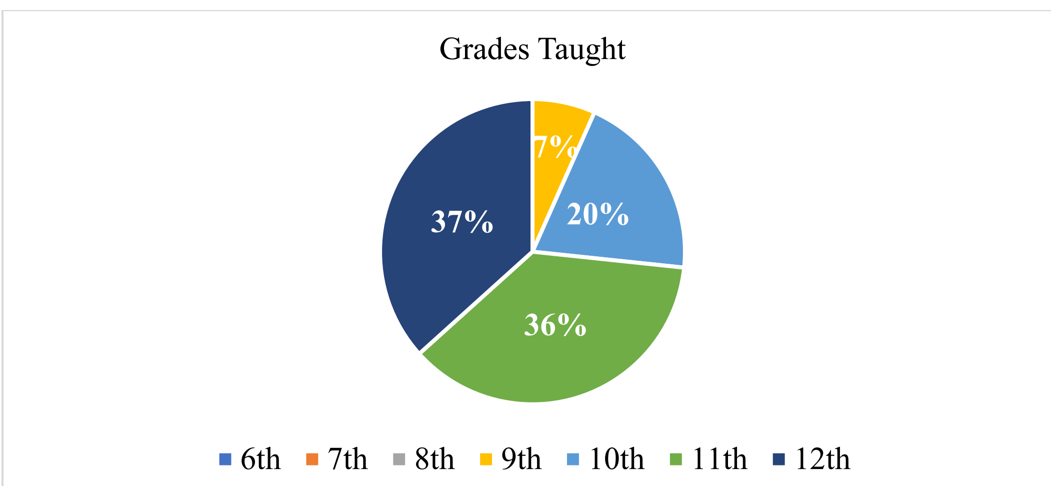

Figure 0-2: Grade Levels of Students Who Performed the Lesson

The lesson was taught in six different subjects: 67% environmental science, 13% physical science, 9% biology, 7% Advanced Placement Environmental Science, and 2% International Baccalaureate Biology and Chemistry (Figure 3). All teachers use formative and summative assessments to evaluate students' academic achievement and understanding throughout the school year.

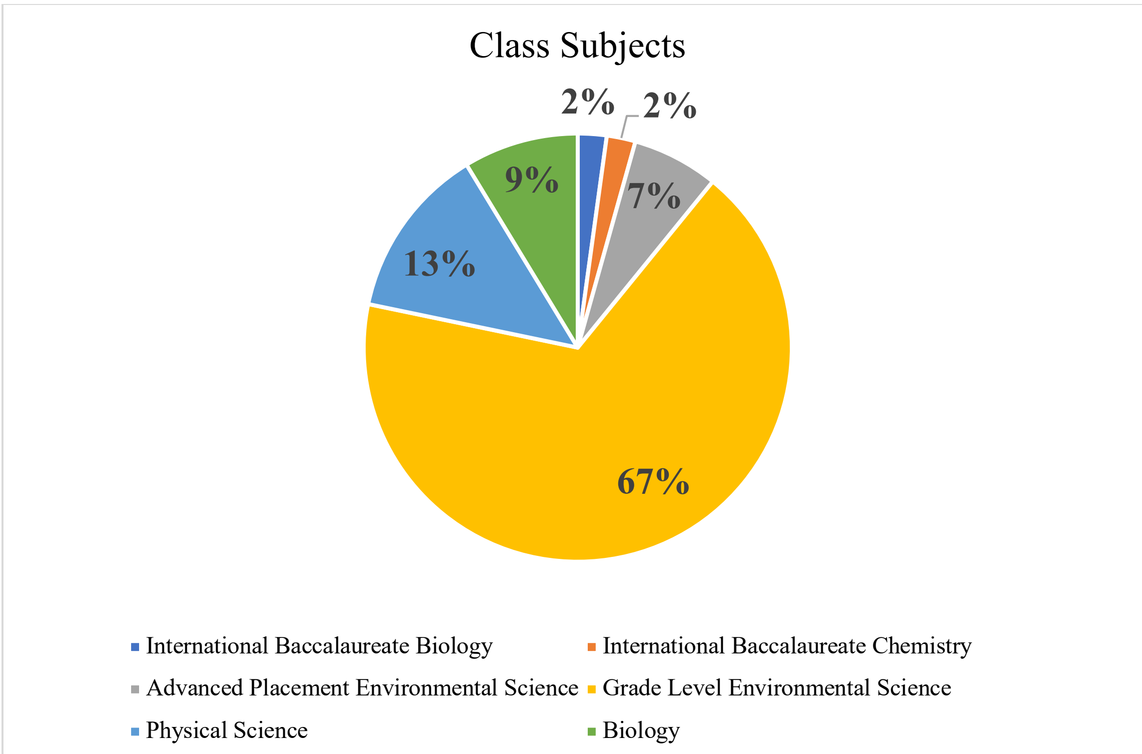

Figure 0-3: Subjects the Lesson was Taught In

Overall, eight of the teachers were located at schools within the Black Belt, while five were not (Figure 4).

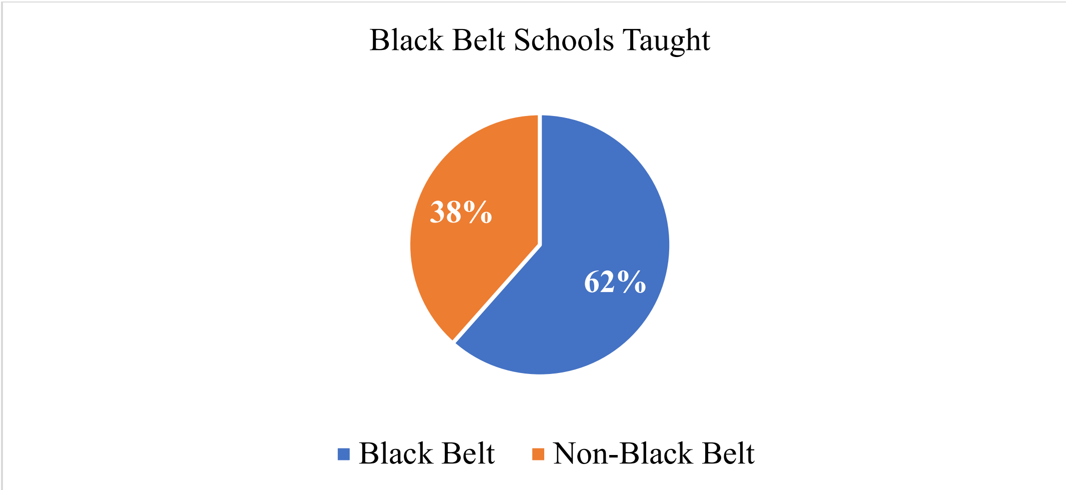

Figure 0-4:Population of Teachers Located in the Black Belt

Schools varied amongst geographical regions with four teachers reporting their schools are in rural communities, four in urban and five suburban (Figure 5). There was no significant relationship between geographic area and Black Belt/Non-Black Belt school district; X^2 (degrees of freedom=2, sample size = 13) = 3.71 (Chi-square value), p = .16.

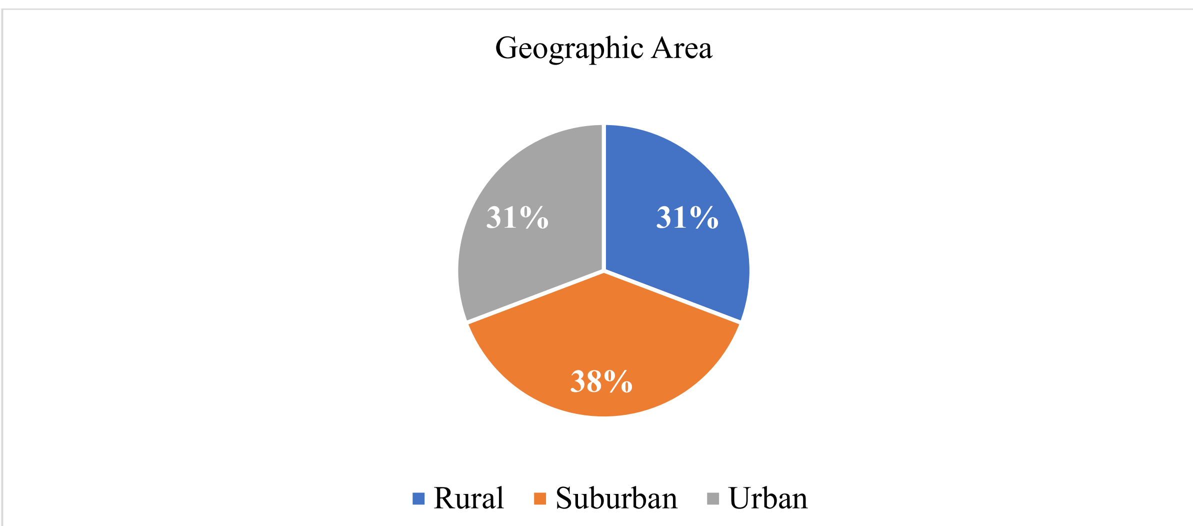

Figure 0-5: Geographic Area Types of Each School According to Teacher Response

1.45.4 Survey Results

Overall, 69.23% of teachers expressed concerns regarding academic resource availability (39% definitely yes, 31% probably yes, 0% might or might not, 15% probably not, 15% definitely not) (Figure 6). Significant differences in concern were not observed between Black Belt teachers (M=3.25, SD=1.04) and Non-Black Belt teachers (M=1.60, SD=1.82); $p = .06$, $d = 1.20$. However, ANOVA results ($p < .001$) and Bonferroni Post Hoc analysis indicate a significant difference between groups, with urban (M=4.00, SD=0.00, $p < .001$) and rural (M=3.25, SD=.50, $p = .007$) schools have higher concerns compared to suburban schools (M=1.00, SD=1.23).

These findings complement previous studies that highlight the unique resource challenges urban and rural school systems face across the country and amongst the South. Overall, studies have found that rural (National Association of State Boards of Education, 2021) and urban school districts (Smedley et al., 2001) are often underfunded, which inhibit access to resources, in comparison to suburban districts. Furthermore, rural schools have been found to have limited access to advanced coursework, extracurricular activities, and digital resources (Croft & Moore, 2019).

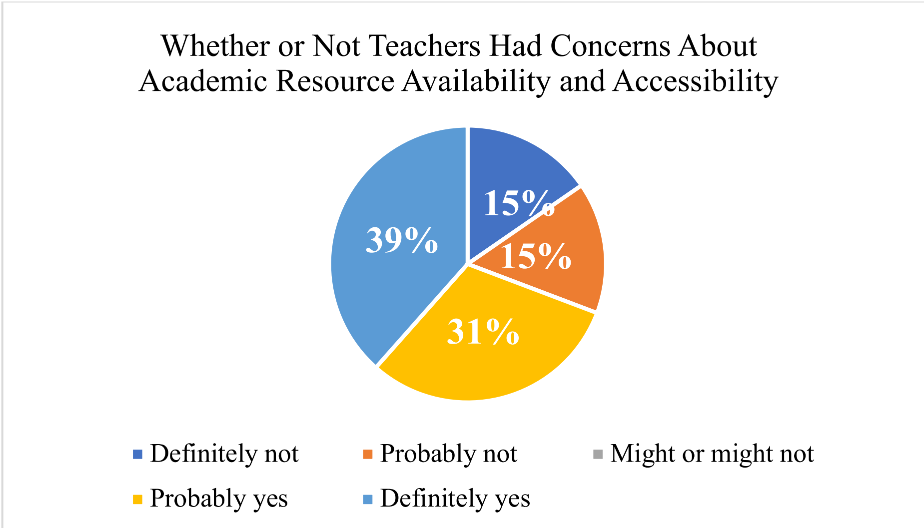

Figure 0-6: Teacher Concerns About Academic Resource Availability

Significant increases were observed amongst all ten student evaluation questions (Q4), as represented in Figure 7. Additionally, internal constancy was observed in both pre (α =.91) and post (α =.73) evaluations of Q4. Question 4 responses were recorded on a Likert scale: 0-strongly disagree, 1-somewhat disagree, 2- neither agree nor disagree, 3-somewhat agree, 4-strongly agree. To begin, perceived student awareness for the environment before the lesson was 2.25 (SD=.97), and the average score after the lesson was 3.33 (SD=.49); p <.001, d=1.37 (Figure 7A). Perceived student belief that climate change is a real global concern increased an average ranking of 2.54 before (SD=1.05) to 3.62 after (SD=.65); p=.02, d =.78 (Figure 7B). Perceived student belief that climate change is a concern for Alabama also increased with an average score of 2.08 (SD=1.12), before the lesson and 3.46 (SD=.66)after; p <.001, d =1.33 (Figure 7C). Perceived students belief that pollution is a concern for Alabama also improved from before (M=2.31, SD=1.03) and after (M=3.38, SD=.96, p=.04, d =.65) (Figure 7D), along with perceived belief that pollution is a global concern: average before 2.85 (SD=1.14), average after 3.77 (SD=.44); p=.02, d =.74 (Figure 7E).

Significant improvements were also observed amongst perceived student feelings regarding water insecurity in Alabama, with an average score of 1.85 (SD=1.21) before and 3.15 (SD=1.07) after; $p=.002$, $d=1.11$ (Figure 7F), perceived student feelings that global water insecurity is a real issue increased 36.5% from averages before (M= 2.08, SD=1.12) and after (M=3.54, SD=.52, $p<.001$, $d=1.51$) (Figure 7G). Overall, teachers reported that student's familiarity with water remediation methods improved from before (M=1.77, SD=1.09) and after (M=3.38, SD=.65, $p<.001$, $d=1.68$) (Figure 7H), as well as with plant-based solutions for environmental challenges with an average score of 1.46 (SD=1.20) before and 3.38 after (SD=.96, $p<.001$, $d=1.46$) (Figure 7I). Lastly, teachers reports that their students' ability to communicate sustainable water remediation methods improved 51.25% from their average scores of 1.31 before (SD=1.18) and 3.23 after (SD=.44, $p<.001$, $d=1.62$) (Figure 7J).

The overall positive trend observed in our study complements previous research employing similar learning approaches, which have also demonstrated notable improvements. To begin, our findings align with research on the implementation of the 5-E learning model, which has shown significant positive outcomes among groups using this structure compared to those that did not (Abdallah Alathameen, 2021). Additionally, studies on task-based learning environments, such as Zhou et al. (2013), have reported comparable results.

Our active learning intervention results are further supported by studies such as Al-Balushi & Al-Aamri (2014), and Derevenskaia (2014), who found positive outcomes in active-learning interventions, including enhanced understanding, improved performance, and increased critical thinking skills. Similarly, our findings are in line with those of Akınoğlu & Tandoğan (2007) and Kontra et al. (2015), who highlight the correlation between hands-on learning and higher student achievement. Moreover, these results support previous work on the impact of relevant learning (Willis, 2007). By investigating and implementing topics of high relevance, such as water quality and Alabama forest product potential, which resonate with all students, participants were more likely to retain and engage with the material. Collectively, these studies reinforce the effectiveness of active learning strategies in fostering academic success and cognitive development

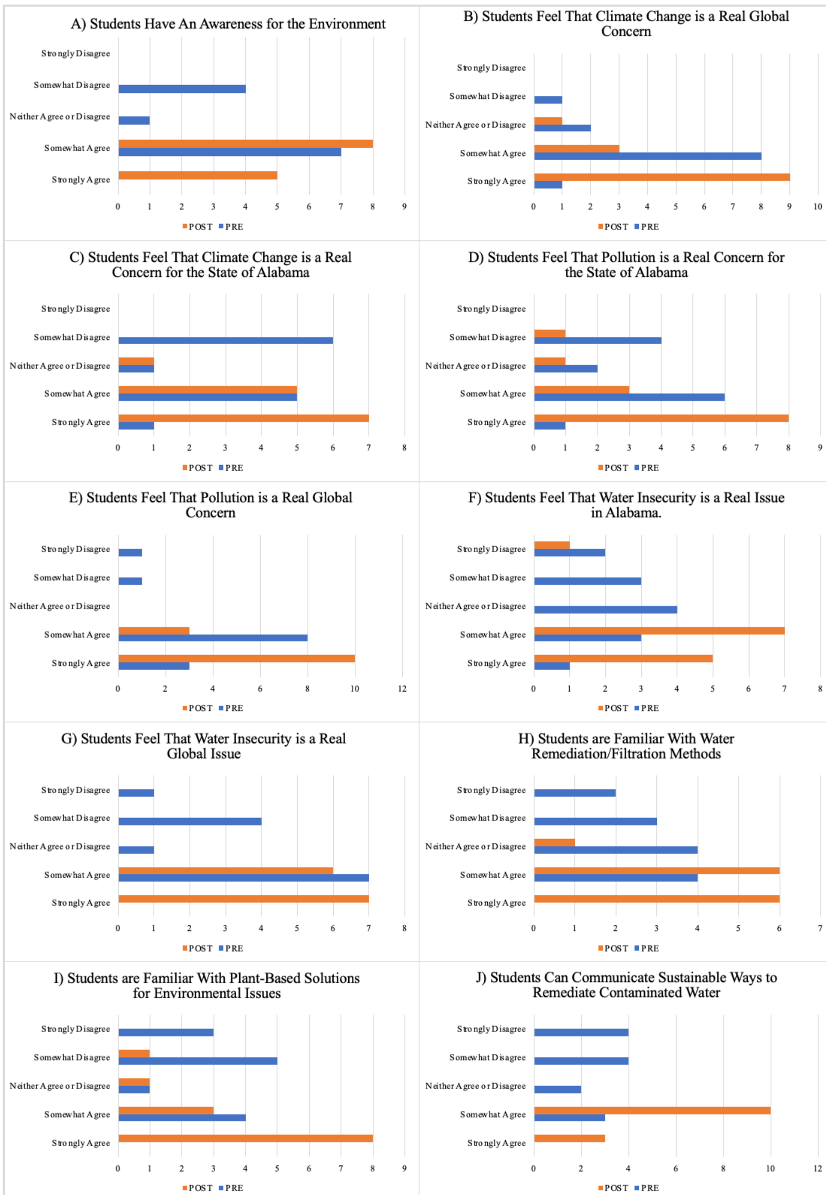

Figure 0-7: Results of Each Student Assessment Question Pre-responses (blue), Post-responses (orange).

Overall, there was a 32.75% increase in scores from before (M=2.03, SD=.82) to after (M=3.43, SD=.39, p <.001, d =1.69) the lesson (Figure 8). This substantial improvement underscores the effectiveness of our instructional intervention, and further supports previously mentioned literature that advocated for active and relevant learning scaffolded through TBL and or 5-E learning. The analysis revealed no significant differences in pre-lesson averages between Black Belt schools (M=1.99, SD=.83) and Non-Black Belt schools (M=2.10, SD=.89; p=.82, d=.13), indicating a comparable baseline level across these groups. Similarly, no significant differences were observed in post-lesson averages between Black Belt schools (M=3.49, SD=.46) and Non-Black Belt schools (M=3.34, SD=.47; p=.53, d=.37), suggesting that the intervention was equally effective in both contexts. Furthermore, the change in pre-post lesson assessment scores did not significantly differ between Black Belt schools (M=1.50, SD=.89) and Non-Black Belt schools (M=1.24, SD=.78; p=.60, d=.31).

A one-way ANOVA analysis also found no significant differences among geographic types regarding pre-lesson averages (p=.77), post-lesson averages (p=.83), or overall difference in scores (p=.06). Rural schools had a pre-lesson average of 2.30 (SD=.81) and a post-lesson average of 3.43 (SD=.29), with an overall average difference of 1.13 (SD=.87). Urban schools had a pre-lesson average of 1.90 (SD=.68), a post-lesson average of 3.58 (SD=.44), and an average difference of 1.67 (SD=.34). Suburban schools had a pre-lesson average of 1.92 (SD=.68), a post-lesson average of 3.32 (SD=.47), and an average difference of 1.40 (SD=.34).

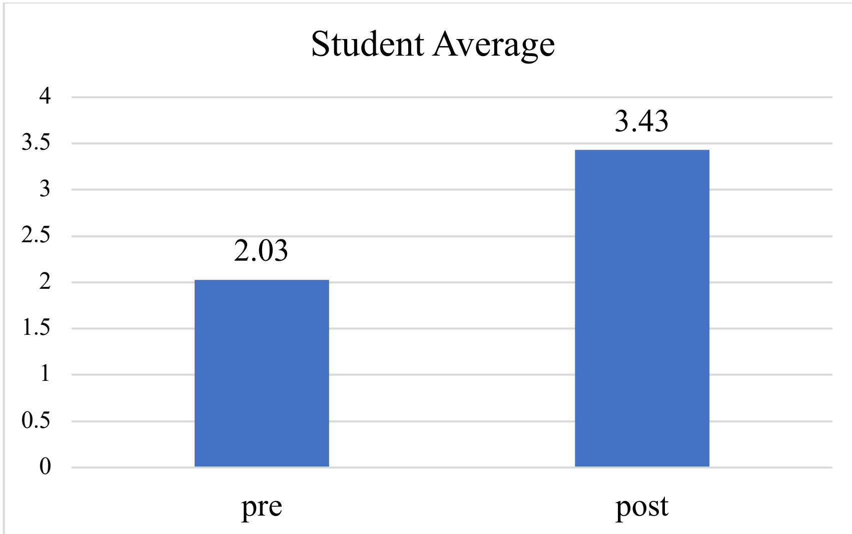

Figure 0-8: Average Student Attitudes Toward Lesson Concepts Before and After the Lesson. Values based off Likert scale: 0-strongly disagree, 1-somewhat disagree, 2- neither agree nor disagree, 3-somewhat agree, 4-strongly agree.

Prior to the lesson, 100% of teachers stated that they strongly believe that having relevant, relatable content on environmental concerns will increase student's environmental awareness (Figure 9A). Following the lesson all teachers expressed belief that the lesson provided relevant, relatable content on environmental concerns and solutions; 69% strongly agreed, 31% somewhat agreed (Figure 9B).

T-test results found that there was a significant difference in this response, with Black Belt believing the lesson was more relevant (M=4.0, SD=0.00) than Non-Black Belt (M=3.20, SD=.45) teachers; p=.02, d=2.97. This result may relate to the higher density of woodlands (Andrew J. Hartsell, 2015; Cartographic Research Lab Department of Geography University of Alabama, 2007), and higher rates of environmental injustices and concerns (Holifield, 2023) located within the region. Results of a one-way ANOVA analysis found no significant difference amongst rural (M=3.75, SD=.50), suburban (M=3.40, SD=.55), and urban (M=4.00, SD=0.00) schools with teacher belief of the relevance of the unit after the lesson (p=.17).

After the lesson, all teachers expressed belief that implementing this unit improved environmental awareness among students; 77% strongly agree, 23% somewhat agree (Figure 9C). Regarding this question, there were no differences observed between Black Belt schools (M=3.88, SD=.35) and Non-Black Belt schools (M=3.60, SD=.55); p=.29, d=.63. Moreover, there were no significant differences observed between rural (M=3.75, SD=.50), suburban (M=3.60, SD=.55), or urban (M=4.0, SD=0.00) schools; p=.43. Additionally, 100% of teachers believed the lesson provided equitable materials, meaning all students were able to learn regardless of background (Figure 9D). There were no notable open responses provided for questions related to the relevance or equity of the lesson.

Overall, teachers' strong belief in the importance of relevant learning, along with their conviction that this lesson was indeed relevant, supports our conclusion that relevance significantly contributed to the increased awareness and understanding observed among the ten-student question. These findings, again, align with Judy Willis (2007) and complement several other studies focused on relevant learning.

Montero & Leite (2022) examined the impact of students developing science missions to address local societal issues that interested them, and they found positive learning outcomes. Similarly, King & Henderson (2018) reported positive achievements among students who learned about water quality at a local creek, outside of the traditional classroom setting. While outdoor learning played a significant role in both studies, they underscore the importance of centering curricula around local, relevant environments—an approach our study also embraced. These findings highlight the potential for future research to explore how learning can be effectively conducted outside traditional classroom settings and how this approach can be made equitable and relevant across various district contexts. Furthermore, Estapa & Tank (2017) demonstrated that using engineering design challenges related to real-world contexts can make learning more relevant and engaging for students. This aligns with our findings, as our lesson involved students designing and engineering their own bio-based filters to treat contaminated water, thereby making the learning experience both practical and pertinent.

Overall, these studies reinforce the significance of relevant, contextualized learning environments in enhancing student engagement and achievement. Our findings contribute to this body of evidence by demonstrating that integrating local and meaningful content into lessons can lead to substantial improvements in student understanding and interest. Future research should continue to explore innovative ways to implement relevant learning both inside and outside the classroom, ensuring accessibility and equity for all students

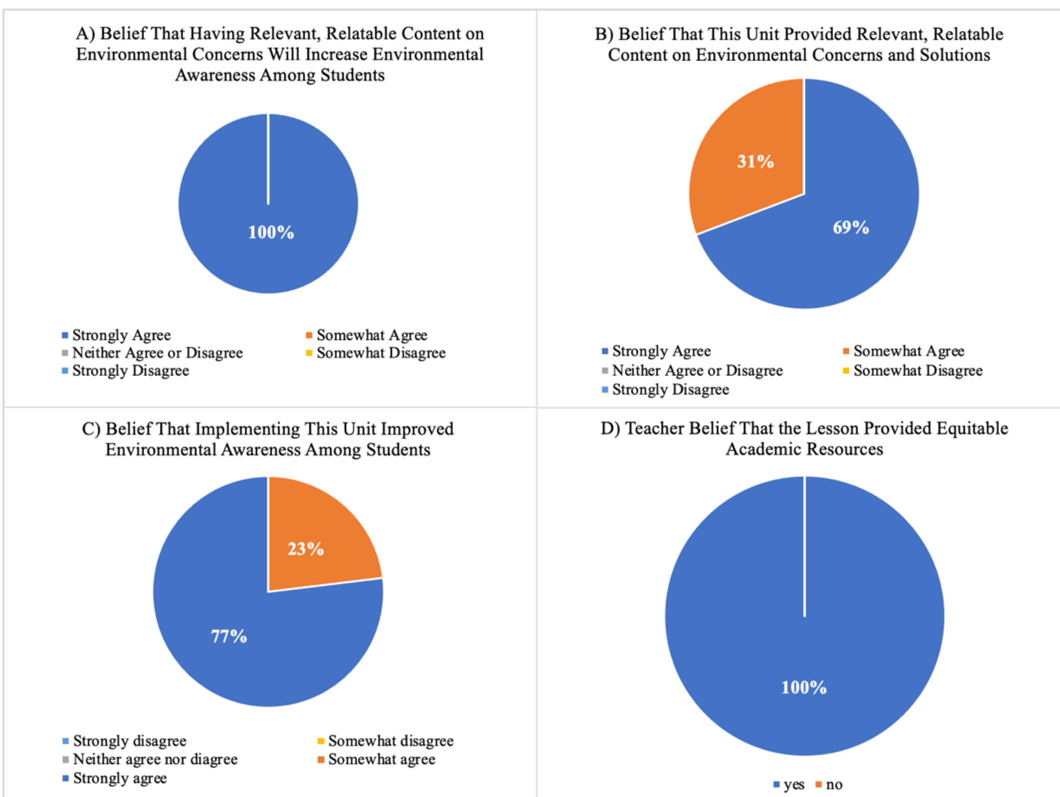

Figure 0-9: Teacher Belief in the Relevance and Equity of the Lesson, and Impact on Environmental Awareness

(A) Relevant Lessons Increasing Environmental Awareness, (B) The Relevance Of The Lesson Studied, (C) Whether The Lesson Increased Environmental Awareness, And (D) The Equity Of The Lesson.

When teachers were asked about their belief that this lesson had the potential to spark interest in environmental careers and studies for students, 55% of teachers responded definitely yes, 18% probably yes and 27% said might or might not (Figure 10). Only 11 out of 13 teachers responded to this question. There were no differences observed between Black Belt schools ($M=3.38$, $SD=.916$) and Non-Black Belt teachers' ($M=3.00$, $SD=.58$) responses; $p=.57$, $d=.63$. Nor were there differences between rural ($M=2.75$, $SD=.96$), suburban ($M=3.0$, $SD= 1.00$), and urban ($M=4.0$, $SD=0.00$); $p=.11$.

While these results indicate that the majority of teachers believed this lesson helped promote career interest and exploration additional methods can be applied to enhance these results. Researchers have recommended introducing changes to the curriculum including enriching formal and non-formal educational activities to again provide engaging and personally relevant experiences in the context of school science and technology, as well as enhancing school-industry collaboration (Reinhold et al., 2018). Additionally, researchers Sheffield et al., (2021) and Rothstein (2015) advocated for the increased diversity and representation of scientists to promote career exploration, especially amongst minority students who often feel they "do not belong" in the field.

Furthermore, aligning with the efforts of this lesson, and previous research, Cohen & Patterson (2012) stress the need to continue to develop relevant and active curriculum to promote career exploration. This claim is further supported by Estapa & Tank (2017) who found that centering lessons around engineering solutions to real-world challenges promote the awareness of the practicality of the learning material, which can foster a deeper understanding and interest in environmental issues and careers among students.

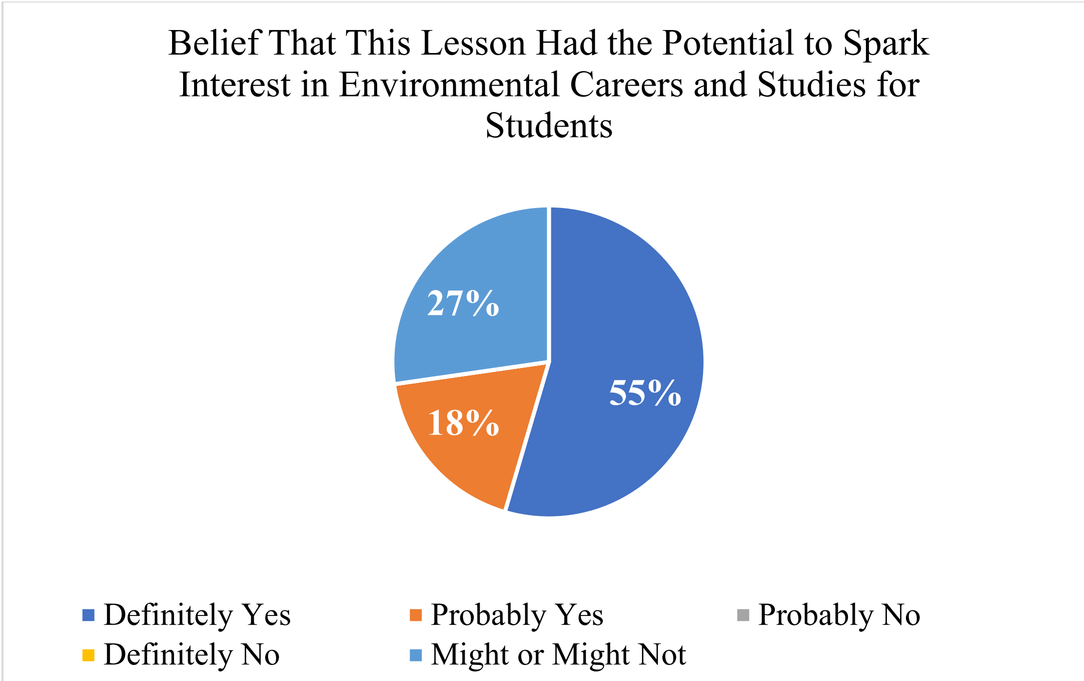

Figure 0-10: Teacher Belief in the Lesson Career Inspiration

Three random teachers were selected to evaluate the validity of the survey, all three stated that they felt our surveys (when compared pre vs post) asked questions that measured whether this lesson impacted students understanding of sustainability, environmental awareness, and science proficiency.

1.46 Conclusion:

The study presented a comprehensive evaluation of an active learning intervention aimed at enhancing environmental awareness and understanding among high school students. The results indicated a significant overall improvement in student scores, with a 32.75% increase from pre-lesson (M=2.03, SD=.822) to post-lesson (M=3.43, SD=.390, p <.001, d=1.69). This substantial gain underscores the effectiveness of the instructional intervention. Importantly, no significant differences were observed in the pre- and post-lesson averages between Black Belt and Non-Black Belt schools, nor among schools in different geographic regions (rural, urban, suburban), demonstrating the broad applicability and effectiveness of the lesson across diverse educational settings.

Teachers' concerns about academic resource availability varied significantly between urban and rural schools compared to suburban schools, reflecting broader systemic issues identified in existing literature regarding resource disparities in these areas. However, the lesson's relevance was strongly supported by teachers, who unanimously agreed that the lesson provided equitable and relatable content that enhanced students' environmental awareness. Significant improvements were observed in all ten student evaluation questions, particularly in areas such as environmental awareness, beliefs about climate change and pollution, and understanding of water insecurity and remediation methods. These improvements align with previous studies that advocate for the use of relevant, and hands-on learning approaches, implemented through methods such as the 5-E learning model and task-based learning.

The positive outcomes of this study support the claims of Judy Willis (2007) and complement the findings of Montero & Leite (2022) and King & Henderson (2018), who emphasized the importance of relevant learning environments. Additionally, the study's findings align with those of Estapa & Tank (2017), reinforcing the value of integrating real-world engineering challenges into the curriculum. Future research should explore innovative methods to implement relevant learning both inside and outside the classroom, ensuring accessibility and equity for all students. This includes developing curricula that provide engaging, practical experiences and fostering school-industry collaborations to promote career interest in environmental sciences. Additionally, increasing diversity and representation in science fields is crucial for encouraging minority students to pursue careers in these areas.

Overall, the study demonstrates that integrating local and meaningful content into lessons can lead to substantial improvements in student understanding and interest, highlighting the effectiveness of active learning strategies in promoting academic success and cognitive development.

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Green Gatherings: Assessing Community Events as Catalysts for Environmental Awareness and Sustainable Practices in Alabama

1.48 Abstract:

Sustainability encompasses the responsible stewardship of resources, ensuring economic prosperity, environmental health, and social equity for current and future generations. To address the urgent need for sustainable practices in Alabama, community events were developed as informal learning interventions to foster understanding and behavior change. These events leveraged psychological frameworks such as the Stages of Change, Social Cognitive Theory, and Social Influence Theory. Survey responses from 2023 and 2024 events indicated significant improvements in participants' understanding and practice of sustainable concepts. Participants also reported increased likelihood to adopt environmentally friendly behaviors, demonstrating the effectiveness of hands-on learning and community involvement. Our study highlights the critical role of outreach and informal education in promoting sustainability and suggests further efforts to engage diverse community members and conduct longitudinal studies to assess long-term impacts.

Keywords: Sustainability, Community Outreach, Active Learning, Informal Learning.

1.49 Introduction and Background:

Sustainability encompasses the responsible stewardship of resources, ensuring that economic prosperity, environmental health, and social equity are maintained for current and future generations (U.S Environmental Protection Agency, 2023). Sustainable development goals (SDG), developed by the United Nations, involve adopting practices that minimize environmental impact, promote social justice, and foster economic resilience (Sachs et al., 2022). The need for sustainable practices has never been more urgent, particularly in regions like Alabama, who currently ranks 45th in the United States in sustainable progress (Lynch & Sachs, 2021) and faces enhanced environmental risks (Carter et al., 2014) and injustices (Holifield, 2023). Addressing these challenges requires not only policy changes and technological advancements but also significant shifts in public behavior and attitudes towards sustainability. Community events designed as informal learning interventions hold significant potential to foster sustainable behavior change by leveraging the principles of psychological frameworks that promote change (Jacobson et al., 2015).

One such framework is the Stages of Change or Readiness for Change Theory, which was first introduced by Prochaska, DiClemente and Norcross in 1992 (Prochaska et al., 1992). This theory states that individuals go through five stages as they begin to adopt a new behavior or belief: 1) Pre-contemplation, 2) Contemplation, 3) Action, 4) Maintenance and 5) Termination. Therefore, to facilitate learning, it is essential to consider where individuals are along this process, and to center educational materials around each stage to accommodate learning. Another theory is the Social Cognitive Theory, which was developed by Albert Bandura in 1986. This theory states that self-efficacy is affected by individuals' self-confidence to control or perform the action (Bandura, 1986). Therefore, to inspire action, it is critical to build individuals' self-confidence within the belief that they can perform change and inspire a sense of control over the issue at hand. Moreover, the Social Influence theory, developed by Herbert Kelman, states that people are heavily influenced by the thoughts and actions of others. Kelman's theory explains that individuals' behaviors and attitudes are influenced through compliance (adopting behavior for rewards or avoiding punishment), identification (conforming to build relationships), and internalization (adopting behavior aligning with personal values) (Kelman, 1958). These processes illustrate how social dynamics shape personal beliefs and actions at different levels of commitment.

One of the common themes throughout these theories, is the belief that our confidence, and environment have a direct impact on our behavior. Therefore, to promote sustainable practices in Alabama, it is essential to provide the opportunity to learn and practice as well as establish a community of citizens eager to adopt environmentally conscious behavior. The need for outreach to promote environmental awareness has been supported by previous researchers, including, Christian et al. (2018) who studied the perspectives and experiences of high school students towards the environment in the state of Alabama. Christian et al. (2018) found that there is a need to design broad environmental literacy and outreach programs in order to motivate and enhance knowledge and significantly increase awareness and involvement of students from minority communities in various fields of environmental science. Community events are a form of informal learning, which is defined as an educational experience that can take place outside of a traditional learning environment and may involve individuals, families, or social groups (J. Bell et al., 2016). Additionally, Lin & Schunn (2016), who conducted a study to measure the effect of informal learning on children in sixth and eighth grade, found that informal learning experiences can have positive impacts on students' attitudes and abilities in science education. Furthermore, informal learning that occurred outdoors or within nature proved to be highly effective in this study. This finding is also supported by an outdoor learning review by Mann et al. (2022), that reported that learning outdoors increased student engagement, self-efficacy, and has helped the development of social and collaborative skills.

Other theories of learning include the Constructivism Theory and active learning. Previous researchers have found that learning is promoted through hands-on activities, also known as active learning. Studies have found that hands-on activities can stimulate motor-related areas of the brain, and when practiced, have shown to improve test scores in students (Kontra et al., 2015). Moreover, active learning centers around solving a problem have been shown to enhance critical thinking, communication, and time management skills (Akınoğlu & Tandoğan, 2007). Constructivism in active learning posits that students construct their own understanding and knowledge through experiences and reflecting on those experiences (Wadsworth, 2003). This approach encourages students to actively engage with the material, collaborate with peers, and apply their knowledge in meaningful contexts. This theoretical framework underpins many active learning strategies, emphasizing the importance of student-centered activities that promote critical thinking and deeper understanding.

1.49.1 Objectives:

The aim of this study was to develop an outdoor community event with active-learning experiences to build confidence and promote change towards environmental awareness and sustainable practices. We hypothesize that by exposing community members to sustainable concepts and practices they will be more likely to understand these concepts and implement them into their lives.

1.50 Methodology

1.50.1 2023 Methodology

1.50.1.1 Planning and Development

In Spring 2023 a planning team of six graduate students and one principal investigator worked to develop a community event, titled "Rallying for Sustainable Communities" at the Kreher Preserve and Nature Center, located in Auburn, Alabama. The event was centered around five hands-on learning activities covering sustainable practices, tailored for elementary school children and their families. The subjects of these lessons included composting, upcycling, recycling and wase separation, recycled paper making and the carbon cycle (Figure 1). First, the compost activity involved participants learning about the purpose of each layer of a compost. In this activity participants made their own compost with edible items, which represented the components of a compost, such as mint leaves, pudding, gummy worms, and fruit (Figure 1A). Secondly, the upcycling station taught participants about how to conserve resources by repurposing items; in this activity recyclables were turning into flowerpots (Figure 1B). Thirdly, at the wase separation activity participants learned about how to properly dispose of common household items, including recycling, composting, thrifting, and specialty items that need to be brought to a disposal facility (Figure 1C). Furthermore, at the recycled paper making station participants learned about this difference between renewable and nonrenewable resources, and how recycling minimizes resource use (Figure 1D). In this station participants were able to replicate a recycling process by making a piece of paper out of recycled newspaper. Lastly, at the carbon cycle activity participants went on a walk across the preserve and stopped at different components of the cycle along the trial (i.e. plants, soil, air/atmosphere) (Figure 1E). Additional volunteers from Auburn University were recruited via email to help facilitate the event.

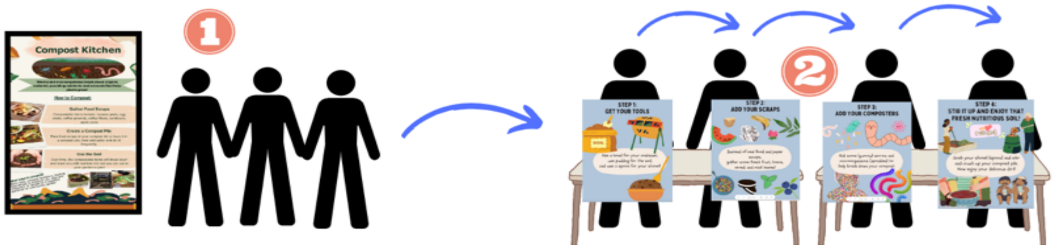
A.

COMPOSTING

Learning objectives:
Participants will learn about the practice of composting, what it is and how it helps the environment and waste disposal challenges. At this station participants will create their own compost through edible items that symbolize components of composting.

Key Ideas:
waste disposal, biodegradation

Organization:
(1) Greeters will meet each participant and talk to them about the learning objectives. Greeters will then introduce the (2) "Compost Specialists" who will discuss the different layers and materials of a compost bin, symbolized by edible materials.



B.

UPCYCLING

Learning objectives:
Participants will learn what upcycling is and how repurposing items contributes to environmental sustainability.At this station participants will learn about upcycling by creating their own hanging planters with recycled cans and bottles.

Key Ideas:
upcycling, recycling, natural resource consumption

Organization:
(1) Greeters will meet each participant and talk to them about the learning objectives. Greeters will then introduce the "Upcycling Separation Specialists" (2) which begins with the selection of a recyled item (3) followed by decorating the item and drilling holes to tie hanging strings and/or pipe cleaners (4) following decorations the pots will be filled with soil, (5) seeds will be planted and the pot will be watered, (6) after the planter is complete volunteers will place the pots on a table at the welcome pavilion .

C.

WASTE SEPARATION

Learning objectives:

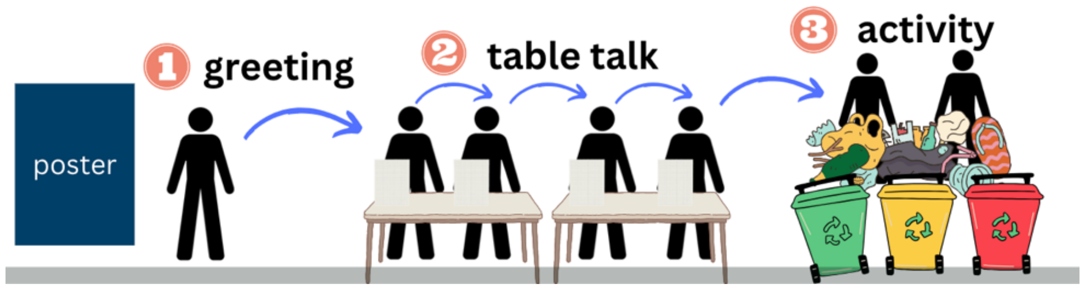
Participants will learn how to properly dispose of waste, and why improper waste disposal is harmful to the environment.At this station participants will learn about several waste disposal options, and will later out their knowledge to the test by separating items in a simulation.

Key Ideas:

renewable vs. nonrenewable resources, biodegation, recycling, composting, thrifting (donations)

Organization:

(1) Greeters will meet each participant and talk to them about the learning objectives. Greeters will then introduce the "Waste Separation Specialists" (2) starting with volunteers who will discuss each separation option (paper, metal and glass, composting, thrifting and donation, garbage) and transitioning to the (3) seperation station where participants will select items and place them in the correct bin.



D.

RECYCLED PAPER MAKING

Learning objectives:

Participants will learn about natural resources (renewable vs non renewable) and how recycling helps preserve our resources. At this station participants will help conserve resources by making NEW paper out of recycled newspaper.

Key Ideas:

renewable vs. nonrenewable resources, what is recycling, how does recycling help our planet.

Organization:

(1) Greeters will meet each participant and talk to them about the learning objectives. Greeters will then introduce the "Paper Specialists", starting with (2)pulp collection (who will remind the participants that the pulp was made from recycled news paper) and ending with (3) decorations (who may emphasize the importance of recycling and repurposing materials)

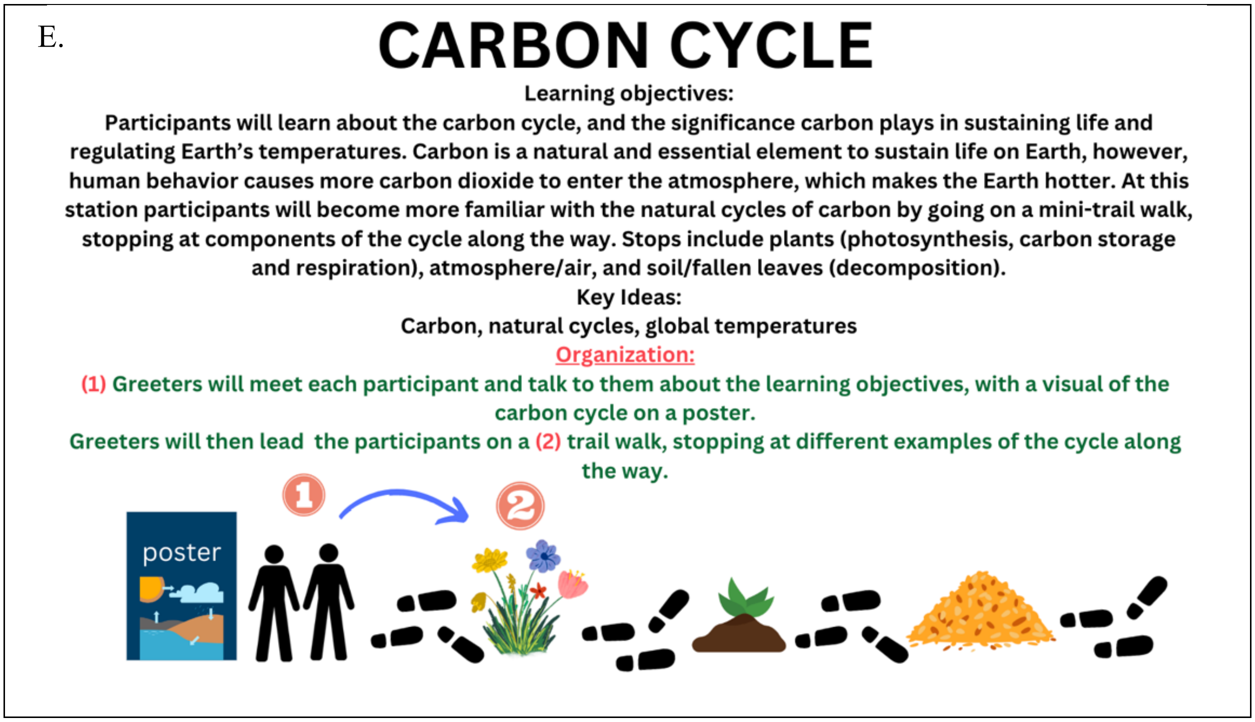


Figure 0-1: Stations at the 2023 Event: (A), upcycling (B), waste separation (C), recycled paper making (D), carbon cycle (E).

1.50.1.2 Participant Recruitment:

Participants were recruited to attend the event via Facebook and word-of-mouth. Digital flyer with details about the event, and a sign-up link were posted on local Facebook group pages.

1.50.1.3 Survey Development:

A post event survey was developed for adult participants to assess their learning and experience. The survey featured questions regarding participants' understanding of concepts covered in the event, impact on environmental awareness, relevance, equity, impact on interest in environmental science and the supporting subjects learned in school, which are listed below. Prior to implementation the survey was assessed and approved by the Institutional Review Board (#22-416 EX 2211). Following the conclusion of the event, a flyer with a QR code of the survey was passed out to adult participants.

Survey Questions:

1. What is your name (open response)
2. Answer the following content-based questions according to your agreement or disagreement after the event: (Likert scale: 5- Strongly agree, 4- Somewhat agree, 3- Neither agree nor disagree, 2- Somewhat disagree, 1- Strongly disagree)
    a. This event helped participants understand what composting is and how it helps the environment.
    b. This event helped participants understand what the carbon cycle is and its role on the environment.
    c. This event helped participants learn how to recycle and properly dispose of waste.
    d. This event helped participants understand what upcycling is and how it helps the environment.
3. Overall, do you believe Rallying for Sustainable Communities increased participants' understanding and awareness of the environment and sustainability?: (Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)
4. Do you believe Rallying for Sustainable Communities provided equitable resources and materials? (all participants were able to learn, interact and engage in materials regardless of personal backgrounds): (Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)
5. Do you believe the lessons this event provided can help increase participants' interest in environmental science? :(Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)
6. Do you believe the lessons this event provided can help support participants' understanding of the environmental science material they may be learning in school?:

(Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)

7. Do you have any comments or suggestions regarding the event and its impact on environmental awareness? (open response)

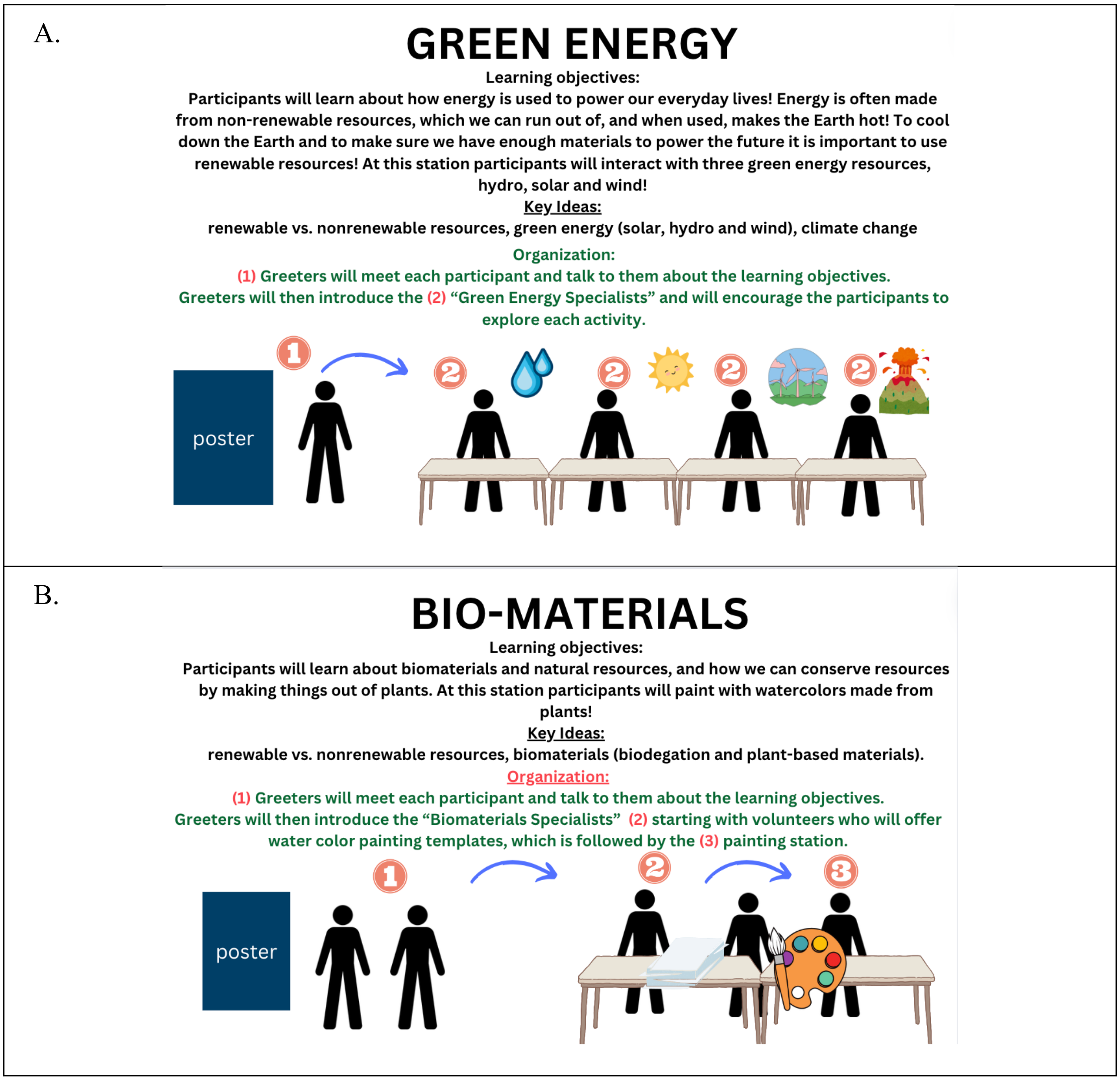
1.50.1.4 Assessment of Results

The results of the survey were assessed through descriptive statistics, the open response feedback question was evaluated through categorical coding. Full descriptions of statistical tests can be seen in section5.

1.50.2 2024 Methodology

1.50.2.1 Planning and Development:

Rallying for Sustainable Communities was organized again for Spring 2024 with seven students, one Alabama Extensions agent, and one principal investigator. Additional volunteers from Auburn University were recruited via email to help facilitate the event. This trial featured the same activities as 2023, however, the carbon cycle was omitted. Four additional activities were introduced, including stations on green energy, biomaterials, native vs. invasive plant species and wildlife (Figure 2). At the green energy station participants explored solar, hydro, geothermal and wind energy sources through toys powered by these energies. At the biomaterials station participants learned about how plants, a renewable resource, can be used to replace nonrenewable commodities; this station featured a painting activity with inks made from plants. At the native vs. invasive plant species activity participants learned about species native to Alabama, and how planting invasive species can be detrimental to the environment; here participants identified and made prints of leaves from native species. Lastly, at the wildlife station, participants interacted with several species that live in Alabama, learning more about who they share the environment with. Additionally, at the event check-in each participant received a pamphlet that held additional resources and information for families to practice each activity at home. Resources included information about recycling facilities, species identification apps, and how-to videos on the activities provided.



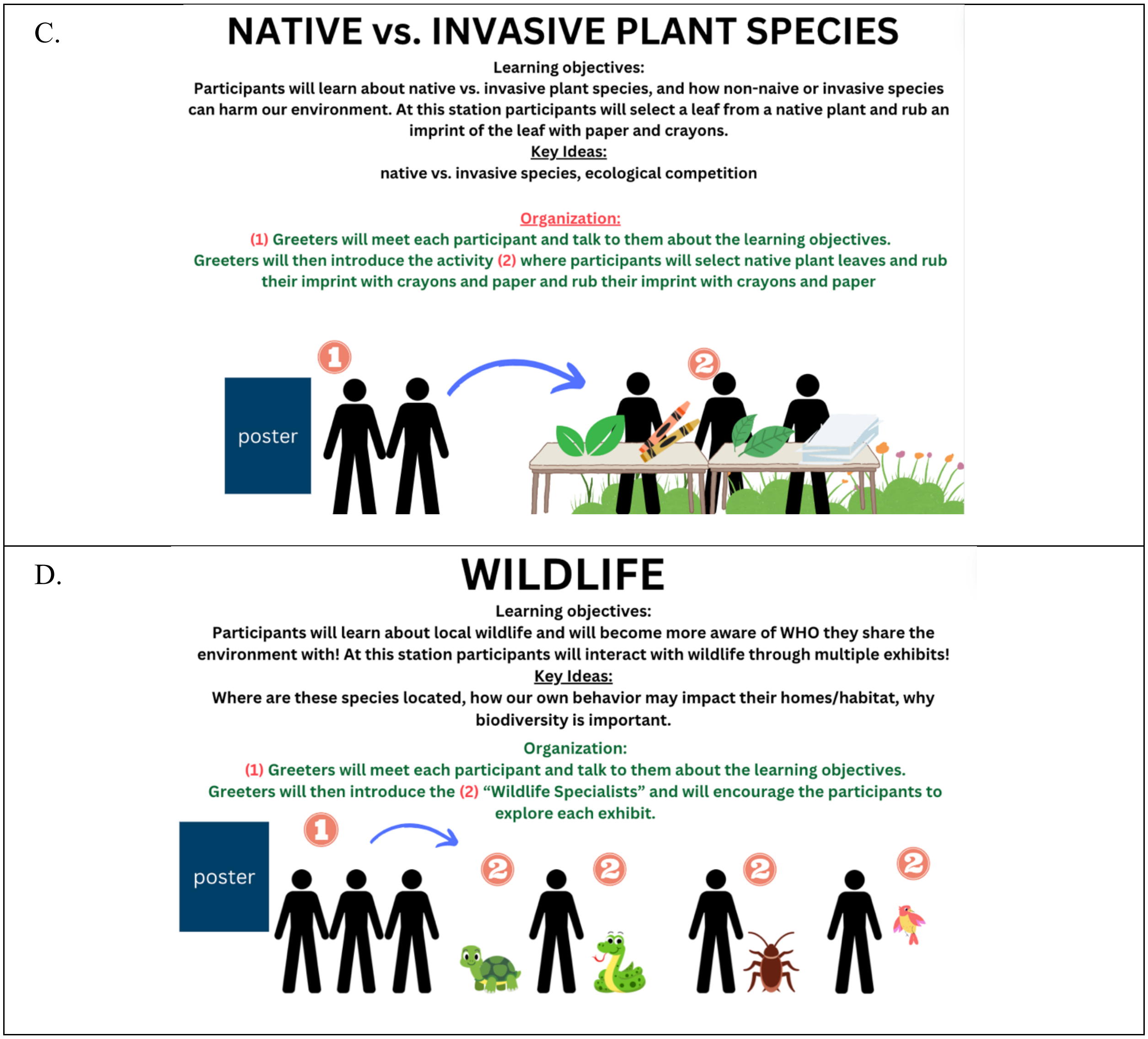


Figure 0-2: Stations Introduced in 2024: green energy (A), biomaterials (B), native vs. invasive species (C), and wildlife (D).

1.50.2.2 Participant recruitment

Similar to 2023, participants were recruited to attend the event via Facebook and word-of-mouth. Digital flyers with details about the event were posted on local Facebook group pages. In addition, invitation emails were sent out to local elementary school principals and after school programs to share the information to families. Transportation was offered and provided to the after-school program, which seeks to serve students in need.

1.50.2.3 Survey Development:

Following the 2023 initial trial, more robust pre- and post-surveys were developed to not only study the impact of learning and understanding, but also changes in behavior amongst different groups of people. Pre-surveys featured demographic questions, as well as participants understanding and practice of the content that will be covered during the event (listed below). The survey concluded with participants ranking their current practice of sustainability and environmental awareness from a scale of 0-100. Pre-surveys were distributed via email after participants signed up to attend the event. Additionally, participants were invited to participate in the survey at the event check-in if they had not already done so. Before implementation, both pre and post surveys were assessed and approved by the Institutional Review Board (#24-716 EX 2402). Additionally, surveys were reviewed for validity and reliability by two third party sources.

Survey Questions

1. What is your name? (open response)
2. How do you describe yourself? (*Qualtrics certified question)
    a. Male.
    b. Female.
    c. Non-Binary/Third Gender.
    d. Prefer to self-describe. (open response)
    e. Prefer not to say.
3. Choose one or more races that you consider yourself to be? (*Qualtrics certified question)
    a. White or Caucasian.
    b. Black or African American.

    c. American Indian/Native American or Alaska Native.
    d. Asian.
    e. Native Hawaiian or Other Pacific Islander.
    f. Other.
    g. Prefer not to say.
4. What is the highest level of education you have completed? (*Qualtrics certified question)
    a. Some high school or less.
    b. High school diploma or GED.
    c. Some college, but no degree.
    d. Associates or technical degree.
    e. Bachelor's degree.
    f. Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.).
    g. Prefer not to say.
5. Do you currently work, have worked, or studied, or are currently studying, in a field of environmental science or sustainability?
    a. Yes
    b. No
    c. Not sure/Maybe
6. Please rank your agreement to the following questions: (Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree)
    a. I understand what sustainability is.
    b. I feel sustainability is important.

c. I feel protecting our environment is important.
d. I feel recycling is important.
e. I feel proper waste management is important.
f. I understand what green energy is.
g. I feel green energy use is important.
h. I understand what composting is.
i. I feel composting is important.
j. I feel protecting wildlife is important.
k. I understand what upcycling.
l. I feel reusing or upcycling materials is important.
m. I understand the difference between native and invasive species.
n. I feel planting native species is important.

7. Please rank the frequency in which you practice the following behaviors: (Likert scale: 5-Always, 4- Most of the Time, 3-About Half the Time, 2-Sometimes, 1-Never)
    a. I recycle.
    b. I practice proper waste disposal.
    c. I compost.
    d. I try to conserve or minimize my energy consumption (i.e. electricity, gasoline/fuel etc.)
    e. I consider where my electricity is coming from/what is made from.
    f. I upcycle or reuse material when possible.
    g. I consider planting native species over non-native species.
    h. I think about how my environmental practices may impact local wildlife.

8. How would you rank your overall practice of sustainability and awareness of the environment (from a scale of 0%-100% with higher numbers representing higher levels of awareness and practices):
    a. Rank your current overall practice of sustainability.
    b. Rank your current overall awareness of the environment.
9. What inspired you to sign up to attend this event? (open response)

The post-event survey featured the same first six questions as the pre-survey, as well as question 6 which was modified to ask the likelihood of practicing those behaviors after the event, and question 7 which was modified to ask participants their likelihood of practicing sustainability and having an awareness of the environment. The post-event survey also featured questions about participants satisfaction of the event, as well as the relevance, equity, likelihood of the increased interest in environmental science, support of material learned in school and open response feedback (listed below).

Additional Post-Survey Questions

- Rank your satisfaction of the event: (Likert scale: 5- Extremely satisfied,4-Somewhat satisfied, 3-Neither satisfied nor dissatisfied, 2- Somewhat dissatisfied, 1-Extremely dissatisfied)
- Do you feel this event was relevant to participants? Did you believe that what you were taught was useful to your present lives, and/or will it help you achieve your future goals?: (Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree)
- Do you believe Rallying for Sustainable Communities provided equitable resources and materials? (all participants were able to learn, interact and engage in materials regardless

of personal backgrounds): (Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree)

- Do you believe the lessons this event provided can help increase participants' interest in environmental science (further learning and/or careers)?: (Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)
- Do you believe this event can help support participants' understanding of the environmental science material they may be learning in school?: (Likert scale: 5- Definitely yes, 4- Probably yes, 3- Might or might not, 2- Probably not, 1- Definitely not)
- Are there any comments or concerns regarding the event that you wish to share? (open response)

1.50.2.4 Assessment of results

Sample populations from each survey were evaluated through descriptive statistics. The differences of pre and post responses, of those who responded to both surveys, were evaluated through paired-samples T-Tests. The overall average pre-post scores from questions 6 and 7, the pre-post rankings of sustainability and environmental awareness (question 9), and the additional questions featured on the post-survey were evaluated between groups (gender, race, education, and experience in environmental science/sustainability work or studies) using a one-way ANOVA. In the event any ANOVA result violated the homogeneity of variance, a non-parametric Kruskal-Wallis test was performed. The open response feedback question was evaluated through categorical coding. Cronbach's Alpha was used to evaluate the internal consistency of a survey items that utilized multiple Likert-scale questions. Full descriptions of statistical tests can be seen in section 4.5.

1.51 Results and Discussion

1.51.1 2023 Results and Discussion

In 2023, 19 children and 15 parents attended the event, nine parents responded to our survey. Overall, 56% of respondents expressed a strong agreement that the event help participants understand what composting is and how it helps the environment, 44% expressed somewhat agree. In regard to the belief that the event help participants understand what the carbon cycle is and its role on the environment, 22% expressed strongly agree, 45% somewhat agree, and 11% neither agree nor disagree, 11% somewhat disagree, and 11% strongly disagree. Additionally, 89% of respondents stated they strongly agree that the event help participants understand how to recycle and properly dispose of waste, and 11% somewhat agreed. Lastly, 78% of respondents stated they strongly agree that the event help participants learn what upcycling is and how it helps the environment, 22% expressed somewhat agree. These responses are visualized in Figure 3. Cronbach's Alpha resulted in questionable internal constancy (α=.62), most likely due to the lower agreement found amongst responses regarding the carbon cycle.

Overall, these findings complement previous studies by Mann et al. (2022), and (Kuo et al., 2019), who reported that learning outdoors increased student engagement, self-efficacy, learning and environmental stewardship. As well others who found that community and outreach events increase the understanding and engagement of environmental science (Baierl et al., 2022; Bell et al., 2009).

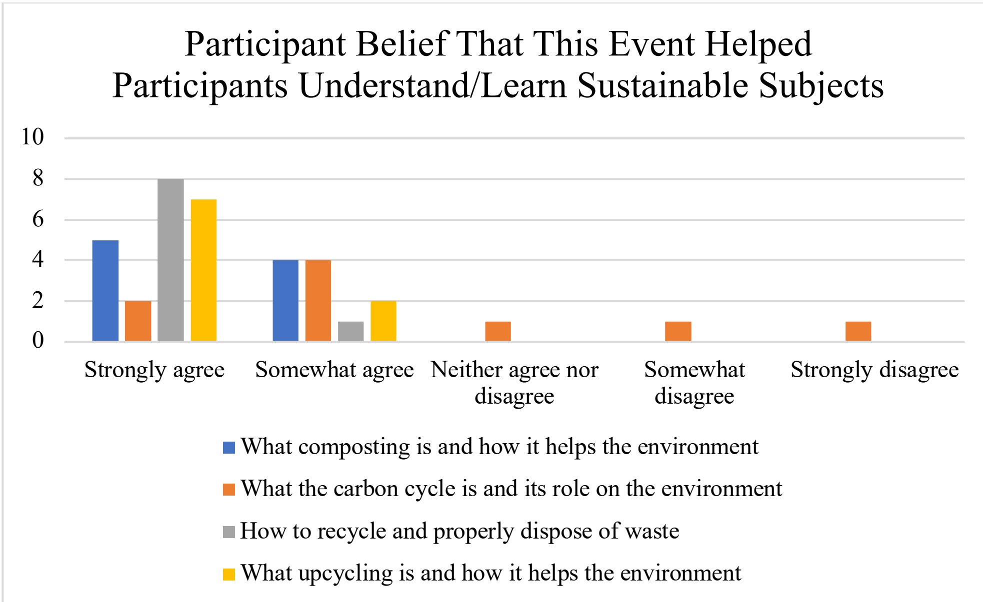


Figure 0-3: Participant Belief In The Events' Impact In Learning And Understanding Of The Concepts Covered

In response to the belief that the event increased participants' understanding and awareness of the environment and sustainability, 56% of respondents expressed definitely yes, and 44% expressed probably yes (Figure 4A). These results complement previous work developed by Baierl et al. (2022) and Bell et al. (2009) who state that environmental outreach promote positive environmental knowledge and attitudes and are crucial for developing interest and capacity for environmental stewardship Additionally, 56% of respondents stated the event definitely provided equitable resources and materials, while 22% stated probably yes, and 22% stated might or might not (Figure 4B). Overall, 56% of respondents stated the event definitely could help increase participants' interest in environmental science, while 33% stated probably yes, and 11% stated might or might not (Figure 4C). Lastly, 56% of respondents stated "definitely yes" when asked if the event can help support participants' understanding of material they may be learning in school, while 33% stated probably yes, and 11% stated might or might not (Figure 4D). These results complement the findings of Kennedy & Odell (2014) who state that community events and outreach play a crucial role in maintaining students' interest and motivation in these subjects.

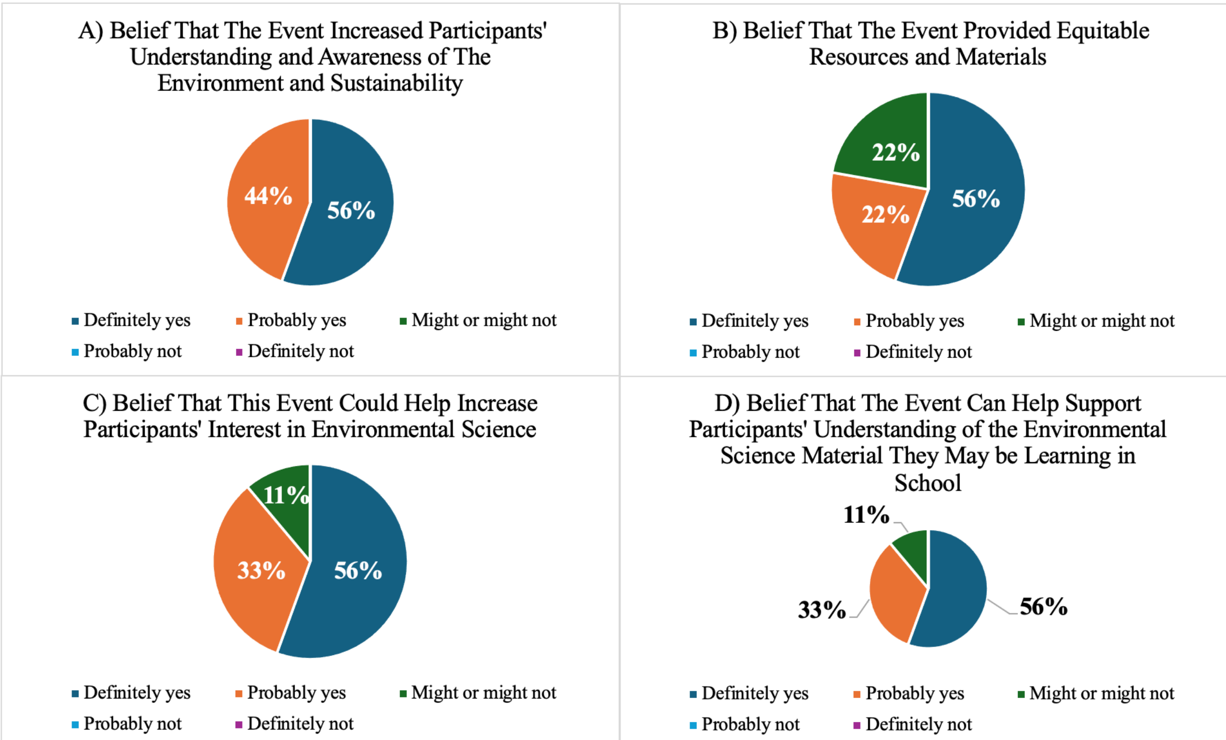


Figure 0-4:Participants' Belief in the Event's Impact of Understanding and Awareness of the Environment and Sustainability, its Equity, Relevance, and Support of Academic Material: (A), its equity (B), relevance (C), and support of academic material (D).

Overall, there were positive responses to the event. One participant stated "loved the activities! My [children] had so much fun, great way to open up these topics for discussion. Another noted, "love how the activities were very hands on. I think it really helps the kids learn the concepts." Another respondent noted the diversity of people in attendance, stating "the event served people from many different communities". Suggestions for the event included better advertising, and additional outreach efforts. One participant stated, "what a great event!! Doing more of them when & wherever possible would be great!". Others suggested participating at other community events or visiting local schools.

1.51.2 2024 Results and Discussion

In 2024, 34 adults and over 50 children attended the event; 23 adults responded to our pre-survey, 16 responded to our post-survey, 13 responded to both surveys. Respondents from pre-event survey were made up of 19 women and four men (Figure 5A). Sixteen individuals identified as White and seven identified as Black or African American (Figure 5B). Eight respondents had graduate degrees, four had bachelors', two had an Associates or technical degree, eight had some college but no degree, and one had a high school diploma or GED (Figure 5C). Three respondents stated to have experience working or studying in a field of environmental science or sustainability, while 19 did not, and one stated not sure/maybe (Figure 5D).

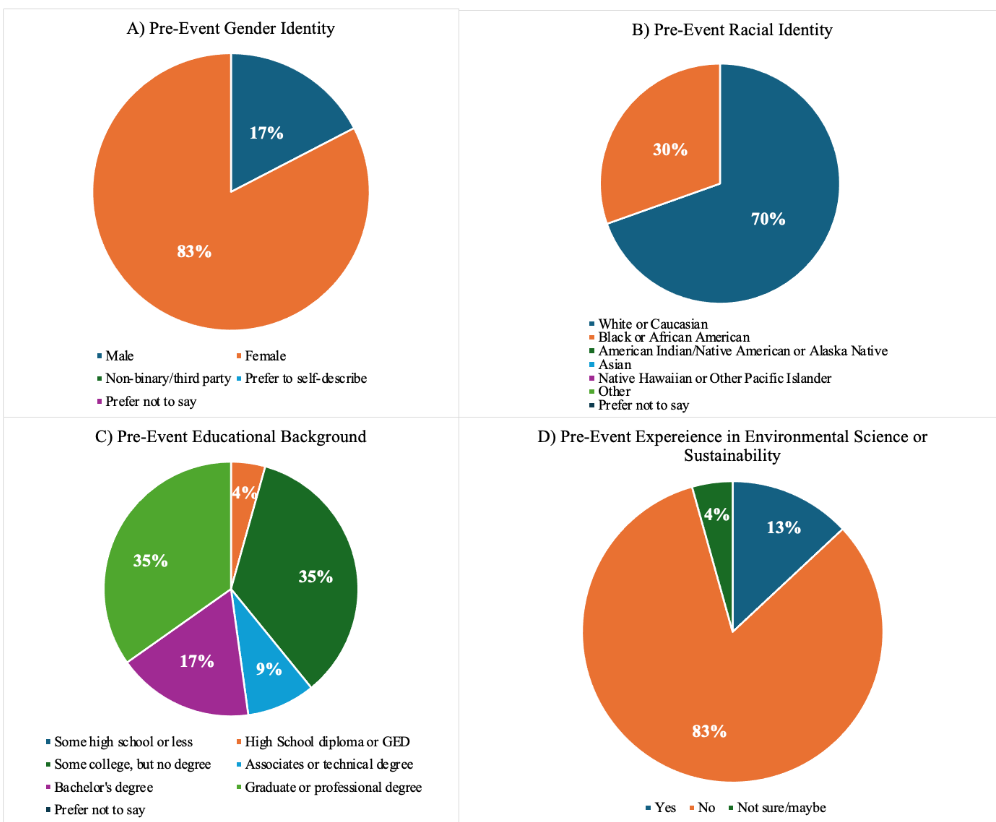


Figure 0-5: Pre-Event Demographics:
(A)Gender Identity, (B)Racial Identity, (C)Educational Background (D)Experience Working Or Studying In A Field Of Environmental Science And Sustainability

From the post-event survey, 14 were women and two were men (Figure 6A). Ten individuals identified as White, five identified as Black or African American, one identified as "other" (Figure 6B). Six respondents had graduate degrees, three had a bachelor's degree, six has some college but no degree, and one had a high school diploma or GED (Figure 6C). Four respondents had experience working or studying in a field of environmental science or sustainability, while 12 did not (Figure 6D).

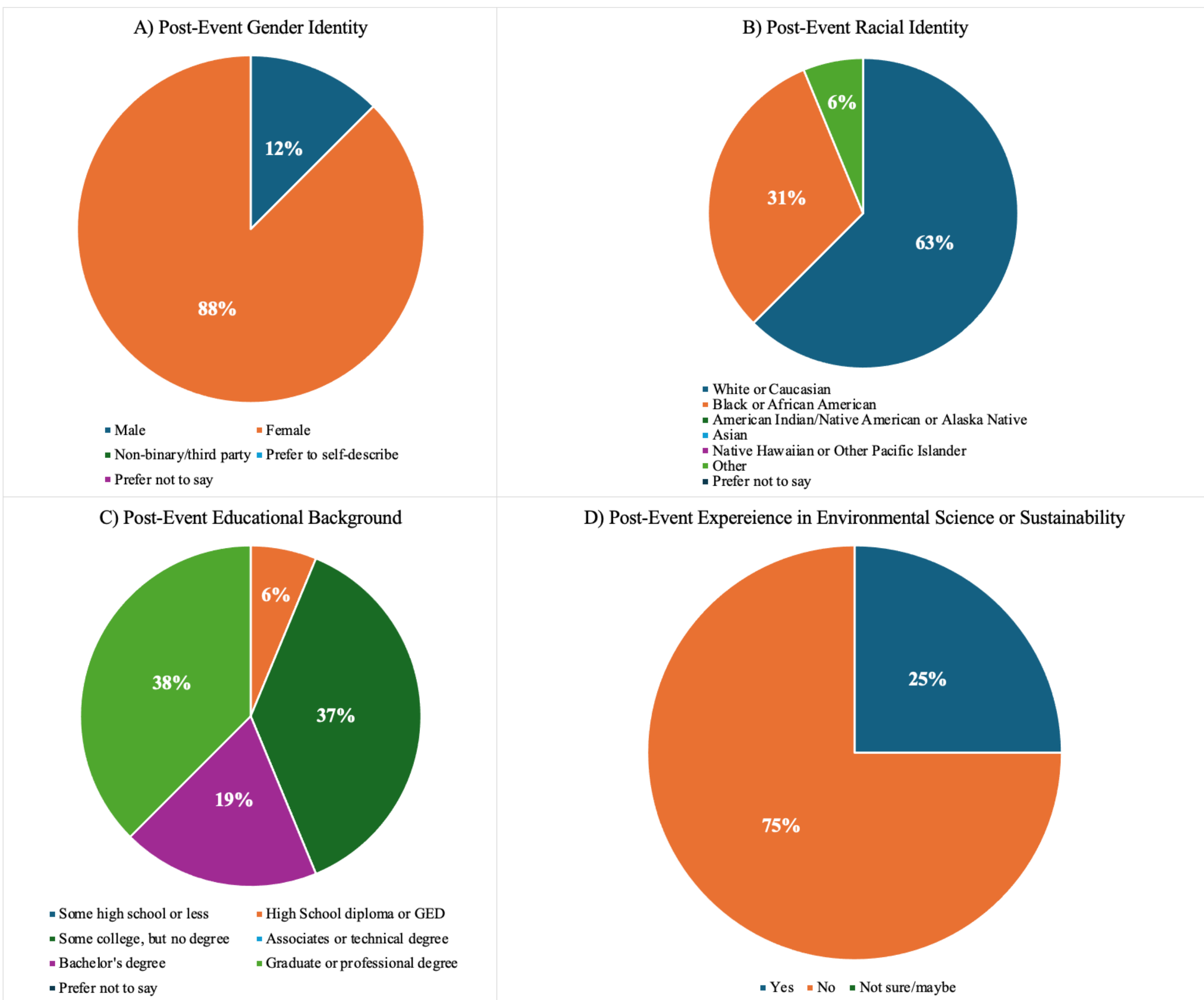


Figure 0-6: Post-Event Demographics
(A)Gender Identity, (B)Racial Identity, (C)Educational Background (D)Experience Working Or Studying In A Field Of Environmental Science And Sustainability

Those who responded to both surveys comprised of 11 women, two men (Figure 7A), 10 individuals who identify as White, three who identify as Black or African American (Figure 7B). Additionally, four had graduate degrees, two respondents had a bachelor's degree, six has some college but no degree, and one had a high school diploma or GED (Figure 7C). Moreover, two had experience working or studying in a field of environmental science or sustainability, while 11 did not (Figure 6D).

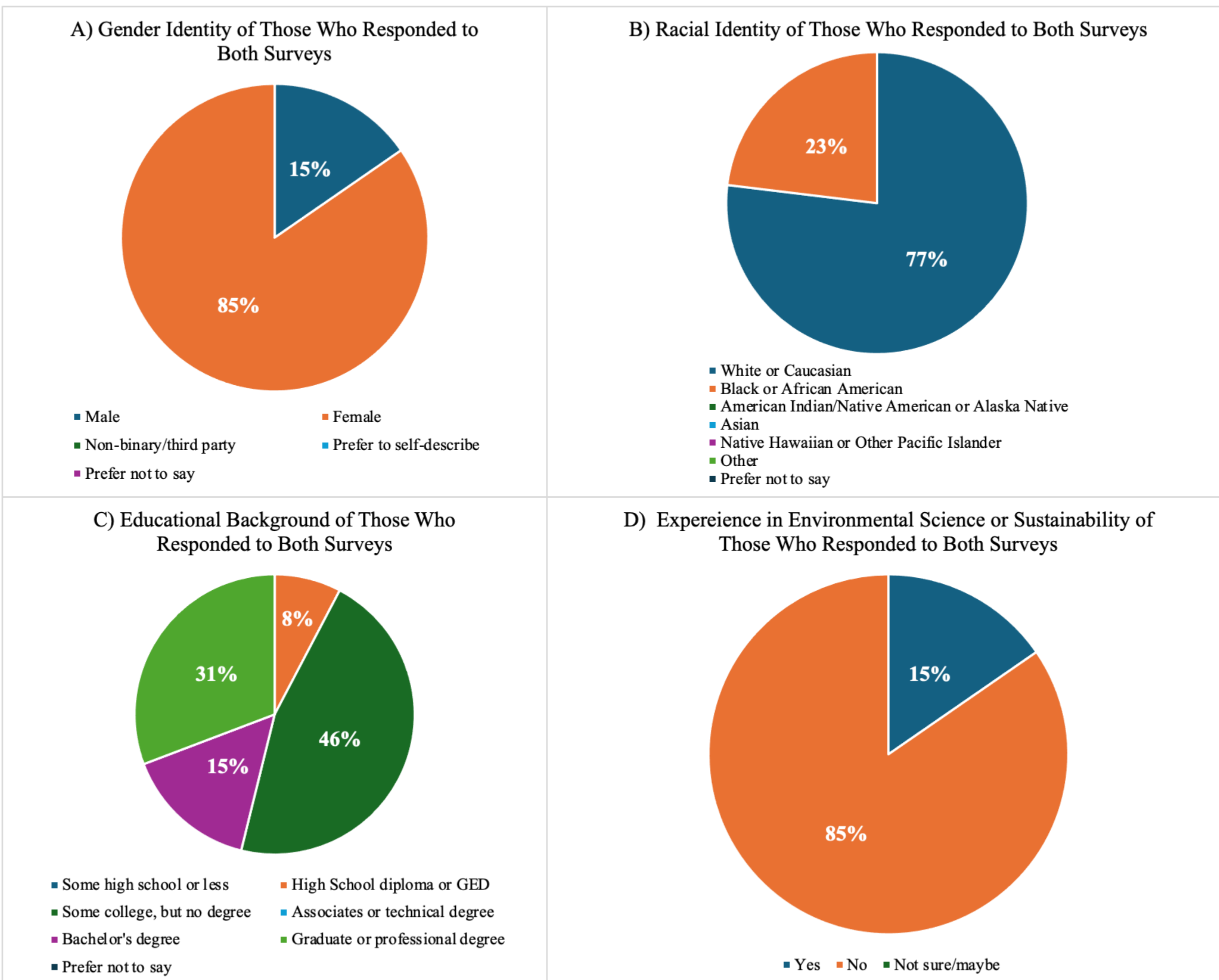


Figure 0-7: Demographics of Participants Who Completed Pre- and Post-Surveys
(A)Gender Identity, (B)Racial Identity, (C)Educational Background (D)Experience Working Or Studying In A Field Of Environmental Science And Sustainability

Internal consistency was found in both pre (α=.85) and post (α=.92) responses regarding the understanding and importance of sustainable practices (question 6). Overall, the majority of our questions regarding the understanding and feeling of importance of the concepts taught resulted in no significant change. This is largely due to participants having a high understanding prior to the event. These findings complement previous research which indicates that community events often face the limitation of primarily engaging individuals who are already supportive or interested in the cause (De Weger et al., 2018). To begin, there were no significant differences observed in participants' understanding of what sustainability is from before (M=4.31, SD=.480) and after the event (M=4.54, SD=.52 p=.19, d=.39) (Figure 8A), nor their belief that it is important from before (M=4.67, SD=.49) and after (M=4.75, SD=.45, p=.34, d=.29) (Figure 8B). Additionally, there were also no significant differences observed in participants' belief that protecting the environment is important from before (M=4.77, SD=.44) and after the event (M=4.85, SD=.38); p=.337, d=.28 (Figure 8C). These findings complement results of the Yale Climate Opinion Maps which found that the majority of Auburn-Opelika citizens believe global warming is happening (71%) and that citizens should do more to address these issues (57%) (Marlon et al., 2023).

Furthermore, no significant differences were observed in participants' feelings that recycling is important from before (M=4.15, SD=.69) and after (M=4.46, SD=.52 p=.17, d=.41) (Figure 8D), nor feelings that proper waste management is important from before (M=4.54, SD=.52) and after (M=4.62, SD=.51); p=.67, d=.12 (Figure 8E). These findings reflect the prior awareness and practice of recycling in this area. According to a report from Auburn University at Montgomery in 2018, over 84% of Auburn citizens participated in local recycling. Furthermore, this report highlights the previous education and outreach efforts performed by the city, with social media posts, website, and interactive games centered around recycling.

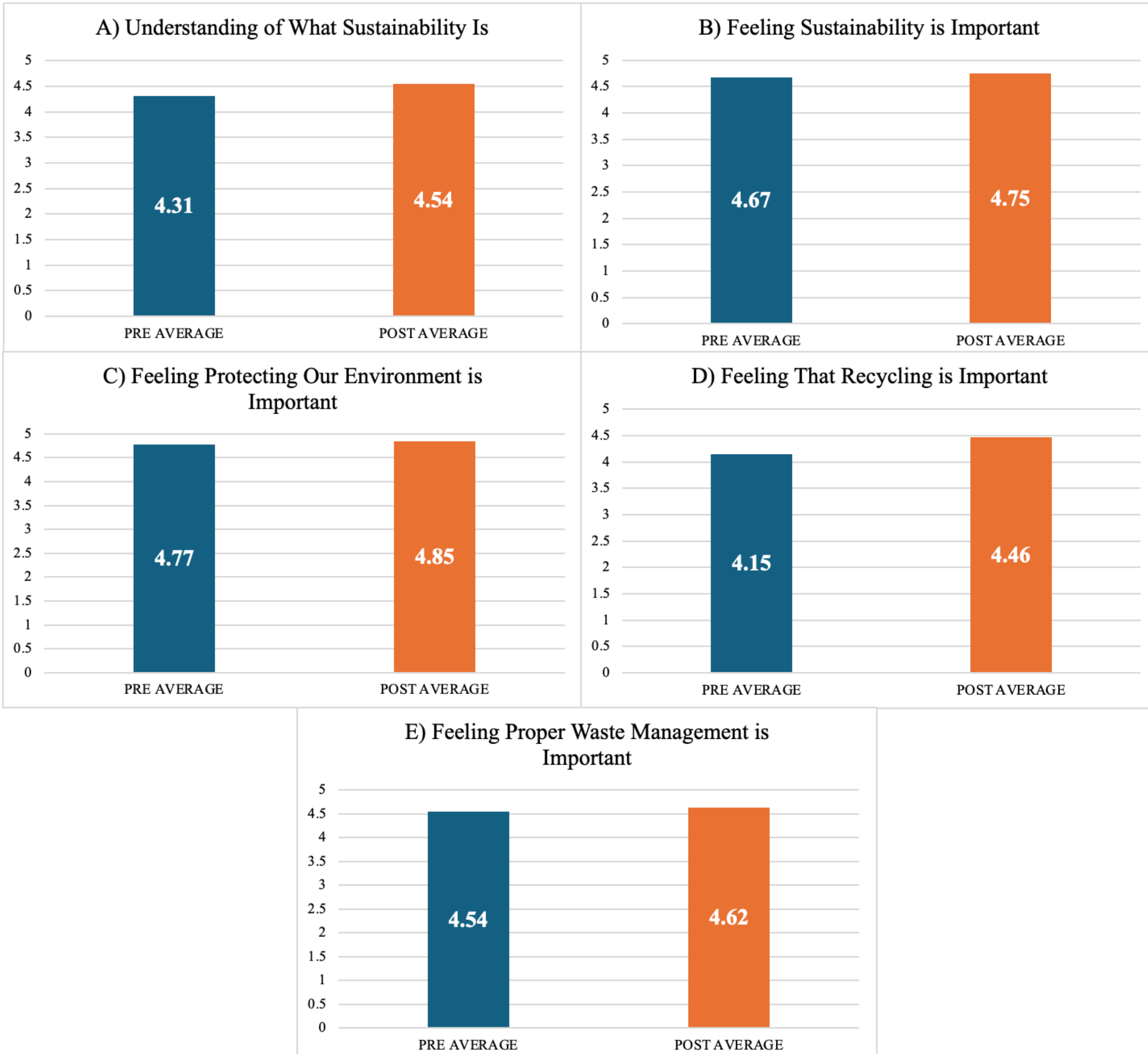


Figure 0-8: Participant Pre and Post Results of Question 6 A-E

Participant pre (dark blue) and post results (orange) of their understanding of what sustainability is (A), feeling that sustainability is important (B), feeling that protecting our environment is important (C), feeling that recycling is important (D), and feeling that proper waste management is important (E). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

There were significant differences observed in understanding what green energy is from before (M= 3.92, SD=.86) and after (M=4.46, SD=.52); p=.03, d=.69 (Figure 9A). However, there were no significant differences observed regarding its importance from before (M=4.15, SD=.80) and after (M=4.54, SD=.88); p=.05, d=.65 (Figure 9b). The general agreement of the understanding and importance of green energy supports finds from the Yale Climate Opinion Maps, with 78% of Auburn-Opelika citizens believing research should be funded into renewable energy sources, and 76% believing renewable energy should be generated on public land (Marlon et al., 2023.).

Similarly, there were significant differences observed in the understanding of what composting is between before (M=4.0, SD=.71) and after (M= 4.62, SD=.65, p=.005, d=.95) (Figure 9C), but no differences in its importance from before (M=4.08, SD=.862) and after (M=4.38, SD=.65);p=.17, d=.41 (Figure 9D). The insignificant difference regarding the importance of composting complement the previous results of the general belief that proper waste management is important, as well as the efforts of the area to practice proper waste disposal (Auburn University at Montgomery, 2018). However the difference in understanding may be related to American misconceptions that composting is difficult (National Waste & Recycling Association, 2014). To promote this practice and to address misconceptions societal support and further educational initiatives are needed. Organizations that practice and exemplify composting have a strong influence on public perception. A study conducted by Waliczek et al. (2016) found a statistically significant difference between student environmental attitudes and knowledge of composting from those who attend schools with a composting program compared to those who do not.

There were also no significant differences observed in participants feelings that protecting wildlife is important from before (M=4.77, SD=.44) and after (M=4.85, SD=.38); p=.34, d=.28 (Figure 9E). The general belief that wildlife protection is important complement the belief of Auburn-Opelika citizens that global warming will harm plants and animals (64%) (Marlon et al., 2023), as well as the positive perception of wildlife conservation and management found in previous work (Heneghan & Morse, 2018; Lessard et al., 2018; Zhang & Zheng, 2011). It is important to note the large population of Alabama citizens who practice outdoor hobbies such as birding and hunting, and how these behaviors contribute to these results (Heneghan & Morse, 2018; Lessard et al., 2018). Moreover, while public attitudes may be positive, these studies, as well as those conducted by Weber Hertel et al. (2023), promote the need for additional education and outreach efforts in Alabama to support successful environmental management, conservation actions, and local participation.

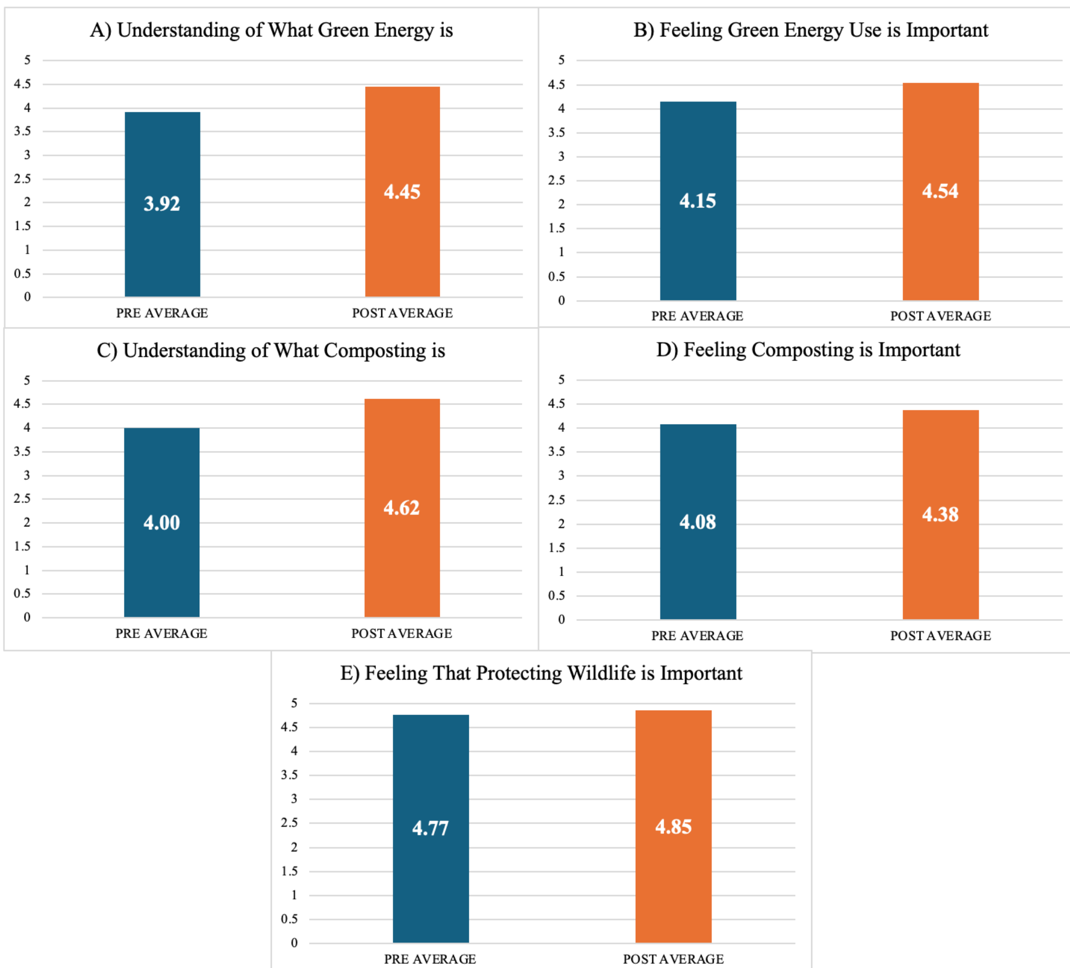


Figure 0-9: Participant Pre and Post Results of Question 6 F-J

Participant pre (dark blue) and post results (orange) of their understanding of what green energy is (A), feeling that green energy use is important (B), understanding of what composting is (C), feeling that composting is important (D), and feeling that protecting wildlife is important (E). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

There were significant differences observed in the understanding of what upcycling is from before (M=3.85, SD=.90) and after (M=4.54, SD=.66); p=.02, d=.73 (Figure 10A). However, there was no differences observed with participants feeling that reusing or upcycling materials is important from before (M=4.08, SD=.76) and after (M=4.46, SD=.66); p=.10, d=.50 (Figure 10B). These results again, complement the previous knowledge and practice of proper waste disposal in the area (Auburn University at Montgomery, 2018).

There were also no significant differences found in understanding the differences between native and invasive species from before (M=4.38, SD=.77) and after (M=4.62, SD=.65); p=.27, d=.32 (Figure 10C). Nor were there differences observed amongst participants feelings that planting native species is important from averages before (M=4.08, SD=.76) and after (M=4.46, SD=.52); p=.05, d=.59 (Figure 10D). The awareness of native vs. invasive plant species may be attributed to previous state efforts and outreach, including those performed by the Alabama Invasive Species Council (Alabama Invasive Plant Council, n.d.), Alabama Forestry Commission (Alabama Forestry Commision, n.d.), Alabama Extensions (Alabama Cooperative Extension System, n.d.), and state education curriculum standards that address this topic (Mackey, 2023).

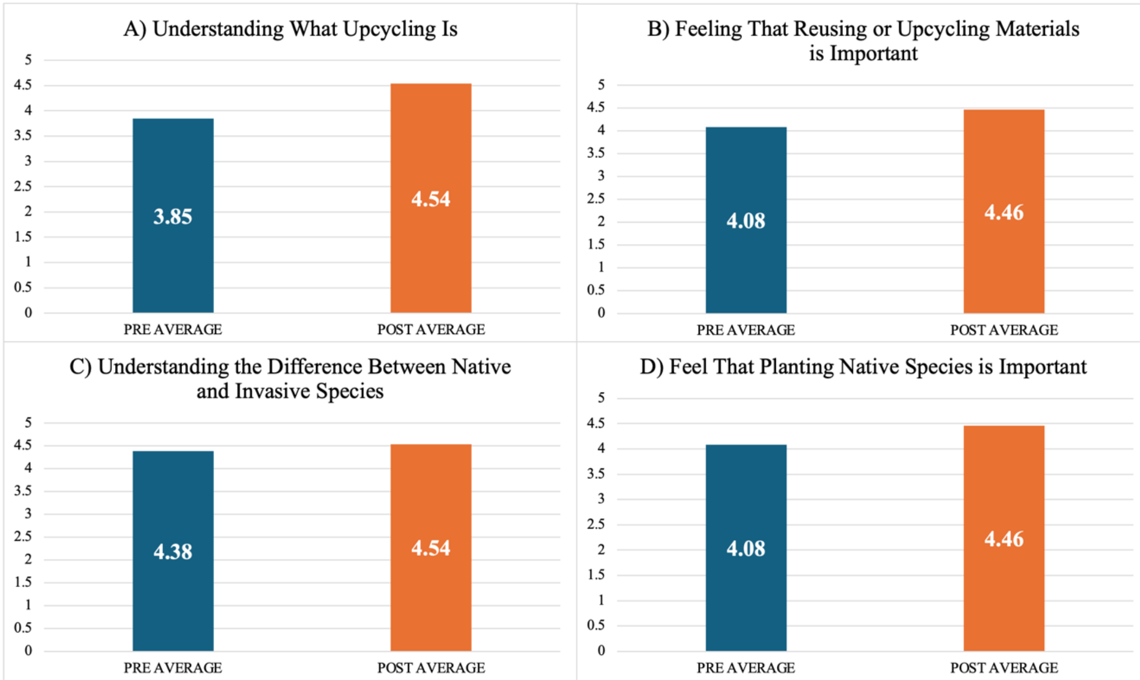


Figure 0-10: Participant Pre and Post Results of Question 6 K-N.
Participant pre (dark blue) and post results (orange) of their understanding of what upcycling is (A), feeling that reusing or upcycling materials is important (B), understanding the difference between native and invasive species (C), and feeling that planting native species is important (D). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

The total combined average of each sub question in question 6 was calculate, and the pre post averages were compared amongst groups. The overall average of question 6 resulted in a significant difference from averages before (M=4.26, SD=.43), and after (M=4.58, SD=4.09); p=.01, d=.80. There were no significant differences found amongst pre-survey averages between males (M=4.35, SD=.38) or females (M=4.31, SD=.42, p=.85), nor post-survey results between (M=4.79, SD=.21) or females (M=4.60, SD=.40, p=.50). Additionally, there were no significant differences found amongst pre-survey averages between respondents who identified as White (M=4.27, SD=.45), or Black or African American (M=4.43, SD=.24); p=.06. Post-surveys found no significant differences between respondents who identified as White (M=4.61, SD=.42), Black or African American (M=4.53, SD=.41), or other (M=4.86); p=.90.

Moreover, no significant differences were found amongst pre-survey averages of participants with high school diploma or GED (M=4.07), some college but no degree (M=4.12, SD=.31), associates or technical degree (M=4.61, SD=.15), bachelor's degree (M=4.27, SD=.52). or graduate degree (M=4.50, SD=.43); p=.58. Post-surveys found no significant differences between high school diploma or GED (M=4.0), some college but no degree (M=4.64, SD=.30), bachelor's degree (M=4.53, SD=.62). or graduate degree (M=4.71, SD=.40); p=.26. Lastly, no significant differences were found in pre-survey results between participants who had previous experience working or studying in a field of environmental science or sustainability (M=4.33, SD=.60), those who didn't (M=4.33, SD=.39), and those who were unsure (M=4.0); p=.29. Nor were there differences observed in post-survey results were those who had experience (M=4.90, SD=.05), and those who did not (M=4.56, SD=.41); p=.07.

The lack of difference amongst groups highlights the effectiveness and relevance of the event as a whole as well as the impact of hands on learning (Akınoğlu & Tandoğan, 2007; Kontra et al., 2015; Wadsworth, 2003). While the average of questions regarding understanding and importance had significant difference, the general lack of difference found amongst each individual question underscore the importance of designing outreach strategies that not only engage the already convinced but also appeal to and educate those who may be indifferent or skeptical about the cause (De Weger et al., 2018). Incorporating diverse outreach methods and targeting varied demographic groups can help broaden the impact of such community events. Incorporating the Diffusion of Innovation Theory can enhance the impact of community events by tailoring outreach methods to different demographic groups (Rogers, 1962). This approach involves understanding adopter categories, leveraging opinion leaders, utilizing appropriate communication channels, encouraging peer-to-peer communication, and addressing specific barriers, thereby ensuring broader and more effective engagement.

While our event may have primarily reached environmentally conscious participants, gathering individuals who support these beliefs cultivated a supportive environment, which according to theory, promotes change (Bandura, 1986; Kelman, 1958). In fact, while most questions related to understanding did not result is significant changes, questions regarding practice did. Internal consistency was observed amongst behavioral questions from before (α=.88) and after (α=.91) the event (question 7). To begin, participant's practice of recycling resulted in significant changes from before (M=3.08, SD=1.26) and after (M=4.31, SD=.86); $p<.001$, d=1.33 (Figure 11A). Also, there were significant differences observed with participant's practice of proper waste disposal from before (M=3.31, SD=1.18) and after (M=4.08, SD=.86); $p=.01$, d=.83 (Figure 11B). Moreover, composting found significant differences from before (M=2.08, SD=1.55) and after the event (M=3.38, SD=1.50); $p=.002$, d=1.11 (Figure 11C). According to the Stages of Change theory (Prochaska et al., 1992), the previous acceptance of the importance and understanding of this topic, would make individuals more likely to change. Moreover by actively performing and practicing recycling and disposal at the event, while being surrounded by a like-minded and supportive environment (Kelman, 1958), the participants confidence may have improved, complimenting what is known about Social Cognitive Theory (Bandura, 1986).

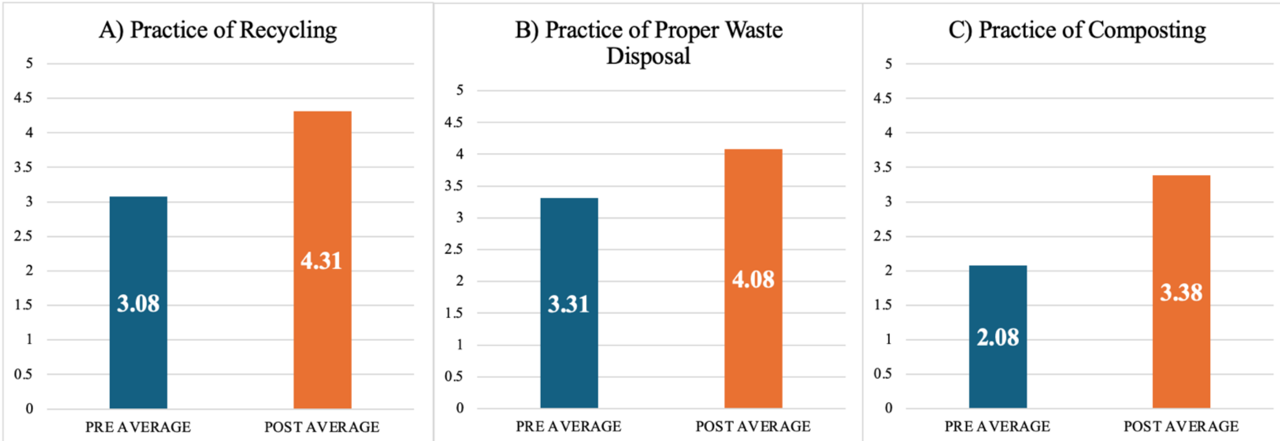


Figure 0-11: Participant Practice, and Likelihood of Practicing Recycling, Proper Waste Disposal and Composting Before and After Event

Participant practice before the event (dark blue), and likelihood to practice after the event (orange) of practicing recycling (A), proper waste disposal (B) and composting (C). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

There were significant differences observed between participant energy conservation before the event (M=3.31, SD=1.11) and likelihood to conserve after (M=4.31, SD=.63); p<.001., d=1.41 (Figure 12A). Additionally, there was a significant different between participant consideration of energy sources before the event (M=2.23, SD=1.36) and after (M=4.23, SD=1.36); p<.001, d=2.00 (Figure 12B). Participant's practice of upcycling also resulted in significant changes from before (M=2.85, SD=1.14) and after (M=4.23, SD=.73); p<.001., d=1.59 (Figure 12C). Similar to the previous results, the prior belief and acceptance of green energy efforts (Marlon et al., 2023) and proper waste disposal (Auburn University at Montgomery, 2018), shown in our results and previous work, would make participants more likely to perform these behaviors (Prochaska et al., 1992), along with instilling confidence through active learning (Akınoğlu & Tandoğan, 2007; Bandura, 1986; Kontra et al., 2015; Wadsworth, 2003) and cultivating s supportive environment (Kelman, 1958).

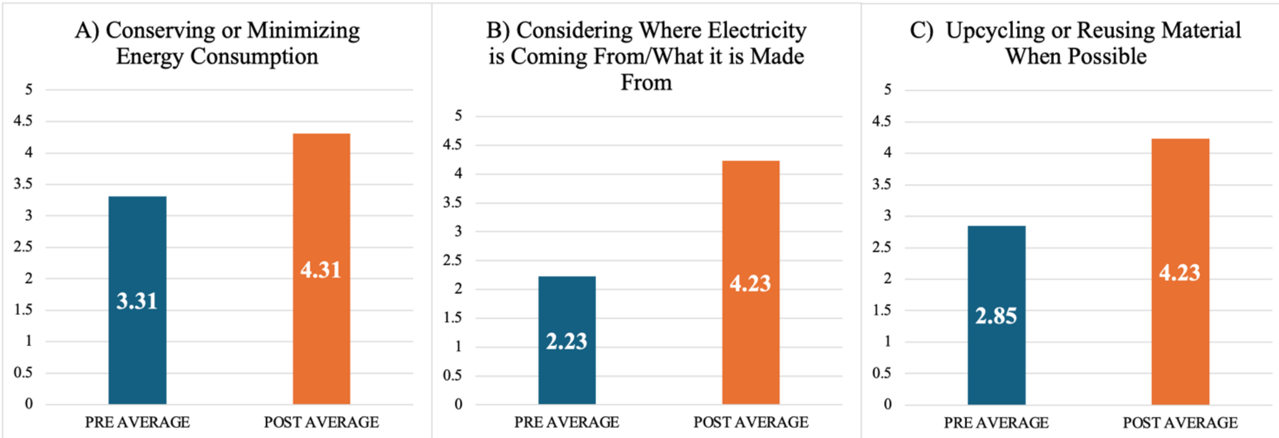


Figure 0-12: Participant Practice, and Likelihood of Practicing the Conservation or Minimization of Energy Consumption, Considering Where Electricity is Coming From, and Upcycling or Reusing Materials When Possible

Participant practice before the event (dark blue), and likelihood to practice after the event (orange) of the conservation or minimization of energy consumption (A), considering where electricity is coming from (B), and upcycling or reusing materials when possible (C). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

Participants were more likely to consider planting native species after (M=3.69, SD=1.38) compared to their practices before (M=2.54, SD=1.61); p=.009, d=.86 (Figure 13A). Lastly, there were significant differences observed with participants' thoughts on how their behavior might impact local wildlife from before (M=3.08, SD=1.320) and after the event (M=4.15, SD=.80); p=.003, d=1.04 (Figure 13B). These results again highlight the significance of prior knowledge and acceptance of these subjects observed Prochaska et al., 1992), the impact of active learning (Akınoğlu & Tandoğan, 2007; Bandura, 1986; Kontra et al., 2015; Wadsworth, 2003) and significance of like-minded social environments (Kelman, 1958).

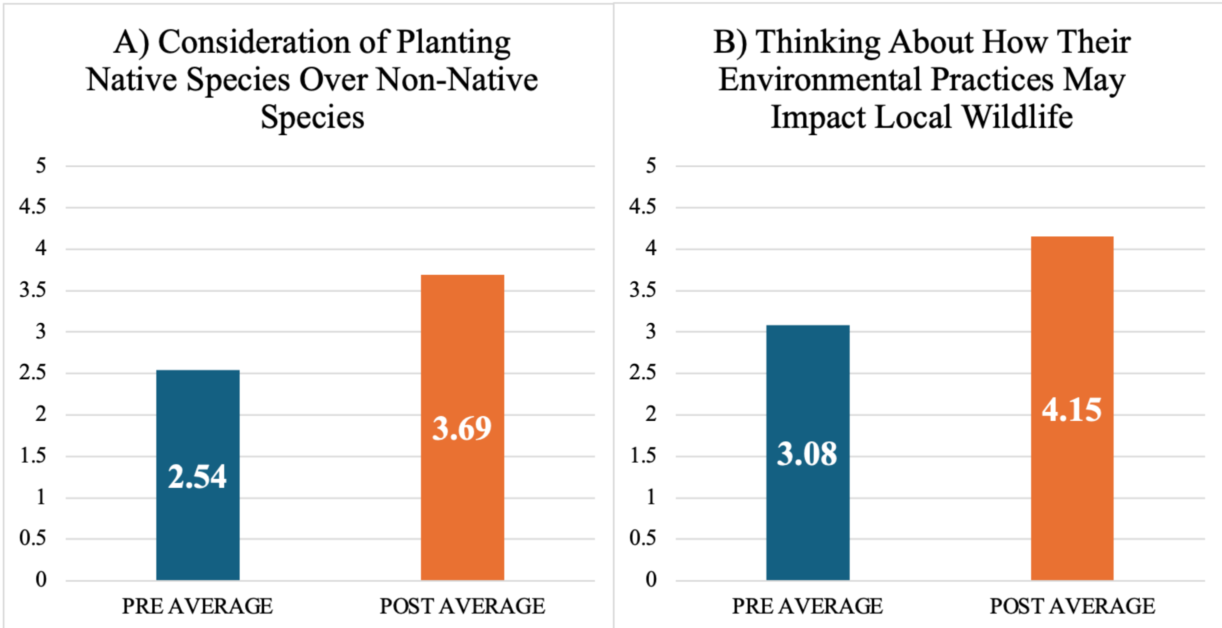


Figure 0-13: Participant Practice, and Likelihood of Practicing the Consideration of Planting Native Species Over Non-Native Species, and Thinking About How Their Environmental Practices May Impact Local Wildlife

Participant practice before the event (dark blue), and likelihood to practice after the event (orange) the consideration of planting native species over non-native species (A) and thinking about how their environmental practices may impact local wildlife (B). Responses were reported using a Likert scale: 5- Extremely agree, 4- Agree, 3- Neither agree nor disagree, 2- Disagree, 1- Extremely disagree.

The average score of each sub question in question 7 were calculated, and the pre-post averages were compared amongst groups in using a one-way ANOVA analysis. The overall average of question 7 resulted in a significant difference from averages before (M=2.81, SD=1.05), and after (M=4.05, SD=.77); p<.001, d=2.07. There were no significant differences found amongst pre-survey averages between males (M=3.32, SD=.68) or females (M=2.81, SD=1.00, p=.35), nor post-survey results between (M=4.51, SD=.53) or females (M=4.06, SD=.76, p=.44). Additionally, there were no significant differences found amongst pre-survey averages between respondents who identified as White (M=3.04, SD=1.03), or Black or African American (M=2.57, SD=.76); p=.29. Post-surveys found no significant differences between respondents who identified as White (M=4.10, SD=.82), Black or African American (M=4.10, SD=.70), or other (M=4.25); p=.98.

Moreover, no significant differences were found amongst pre-survey averages of participants with high school diploma or GED (M=1.50), some college but no degree (M=2.66, SD=.78), associates or technical degree (M=3.80, SD=0.00), bachelor's degree (M=2.31, SD=.80). or graduate degree (M=3.49, SD=1.01); p=.09. Post-surveys found no significant differences between high school diploma or GED (M=4.00), some college but no degree (M=3.92, SD=.86), bachelor's degree (M=4.25, SD=.74), or graduate degree (M=4.25, SD=.77); p=.89. Lastly, no significant differences were found in pre-survey results between participants who had previous experience working or studying in a field of environmental science or sustainability (M=3.543, SD=1.45), those who didn't (M=2.82, SD=1.45), and those who were unsure (M=2.38); p=.44. Nor were there differences observed in post-survey results were those who had experience (M=4.31, SD=.80), and those who did not (M=4.08, SD=.75); p=.69.

Significant differences were observed in participants ranking of their practice of sustainability before the event (M=59.62, SD=25.66) and likelihood after the event (M=86.00, SD=15.44); p<.001, d=1.29 (Figure 14). There were no significant differences found amongst pre-survey averages between males (M=68.50, SD=22.03) or females (M=58.16, SD=24.38, p=.44), nor post-survey results between (M=96.00, SD=5.66) or females (M=85.08, SD=15.41, p=.35). Additionally, there were no significant differences found amongst pre-survey averages between respondents who identified as White (M=57.94, SD=25.19), or Black or African American (M=64.57, SD=21.53); p=.55. Post-surveys found no significant differences between respondents who identified as White (M=85.90, SD=16.89), Black or African American (M=84.79, SD=10.37), or other (M=100.00); p=.67.

Moreover, no significant differences were found amongst pre-survey averages of participants with high school diploma or GED (M=39.00), some college but no degree (M=63.50, SD=20.62), associates or technical degree (M=77.50, SD=3.54), bachelor's degree (M=49.50, SD=30.39) or graduate degree (M=59.88, SD=30.39); p=.63. Post-surveys found no significant differences between high school diploma or GED (M=77.00), some college but no degree (M=85.33, SD=18.41), bachelor's degree (M=87.33, SD=21.94), or graduate degree (M=89.40, SD=8.47); p=.91. Lastly, no significant differences were found in pre-survey results between participants who had previous experience working or studying in a field of environmental science or sustainability (M=66.67, SD=32.15), those who didn't (M=59.21, SD=23.88), and those who were unsure (M=54.00); p=.86. Nor were there differences observed in post-survey results were those who had experience (M=97.50, SD=3.54), and those who did not (M=84.85, SD=15.27); p=.28.

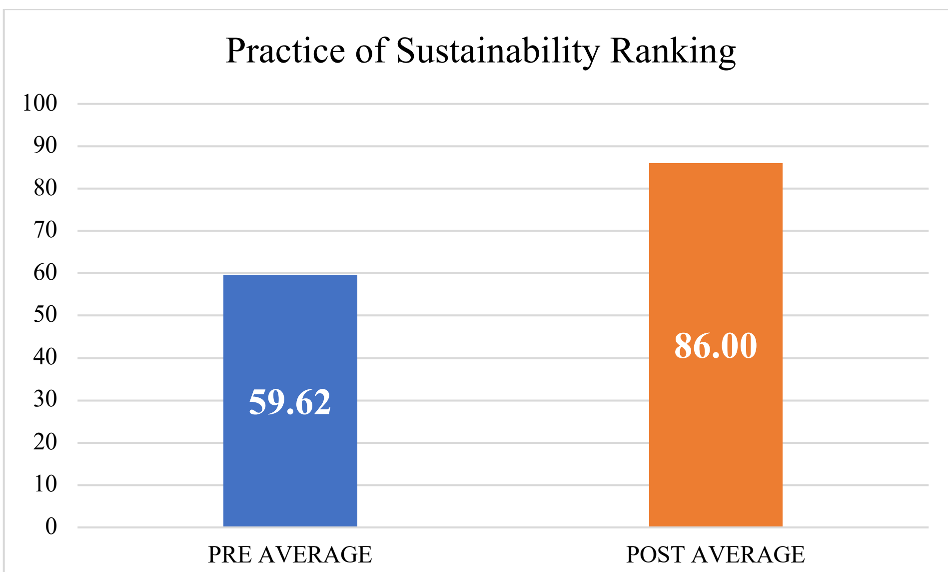


Figure 0-14: Participant Ranking of Their Practice and Likelihood of Practicing Sustainability
Participant ranking of their practice before the event (dark blue) and likelihood of practicing sustainability after the event (orange). Responses were recorded from a scale of 0%-100% with higher numbers representing higher levels of practices.

The overall change in behavior and increased likelihood to practice sustainability complement previous outreach studies and efforts. Stapleton et al. (2022) who studied effective outreach efforts to promote environmentally conscious behavior emphasized the importance of using behavioral science principles to encourage sustainable actions, as we did within our work through the use of the Stages of Change Theory, Social Cognitive Theory, and Social Influence Theory. Additionally, Stapleton et al. (2022) discussed the impact of effective communication strategies, such as providing actionable steps, which was explored in our study through hands-on learning activities. Moreover, Ardoin et al. (2020), who developed a systematic review on environmental education outcomes for conservation, highlighted the positive results and impact of community-based events on establishing long-term sustainable behavior.

Along with increases in the likelihood of sustainable practices, significant differences were observed in participants ranking of their environmental awareness before the event (M=72.00, SD=23.50) and likelihood after the event (M=89.08, SD=9.71); p=.02, d=.78. There were no significant differences found amongst pre-survey averages between males (M=77.75, SD=16.46) or females (M=71.84, SD=19.63, p=.58), nor post-survey results between (M=96.00, SD=5.66) or females (M=88.54, SD=9.73, p=.32). Additionally, there were no significant differences found amongst pre-survey averages between respondents who identified as White (M=70.56, SD=20.74), or Black or African American (M=78.14, SD=13.74); p=.39. Post-surveys found no significant differences between respondents who identified as White (M=90.70, SD=10.24), Black or African American (M=84.00, SD=4.97), or other (M=100.00); p=.27. Moreover, no significant differences were found amongst pre-survey averages of participants with high school diploma or GED (M=96.00), some college but no degree (M=68.00, SD=20.15), associates or technical degree (M=85.00, SD=7.07), bachelor’s degree (M=63.75, SD=26.58), or graduate degree (M=76.38, SD=14.15); p=.43. Post-surveys found no significant differences between high school diploma or GED (M=78.00), some college but no degree (M=91.67, SD=10.37), bachelor's degree (M=87.67, SD=13.65), or graduate degree (M=90.40, SD=6.69); p=.64.

Following an ANOVA analysis of pre-survey results of previous experience working or studying in a field of environmental science or sustainability, the pre-environmental awareness ranking results violated the Levene's test of homogeneity of variance, therefore a non-parametric Kruskal-Wallis test was performed. The results of the Kruskal-Wallis test found that there were no differences observed between participants who had previous experience working or studying in a field of environmental science or sustainability (M=72.67, SD=37.17), those who didn't (M=73.74, SD=16.39), and those who were unsure (M=57.00); p=.38. There were also no differences observed in post-survey results between those who had experience (M=97.50, SD=3.54), and those who did not (M=88.31, SD=.9.60); p=.21.

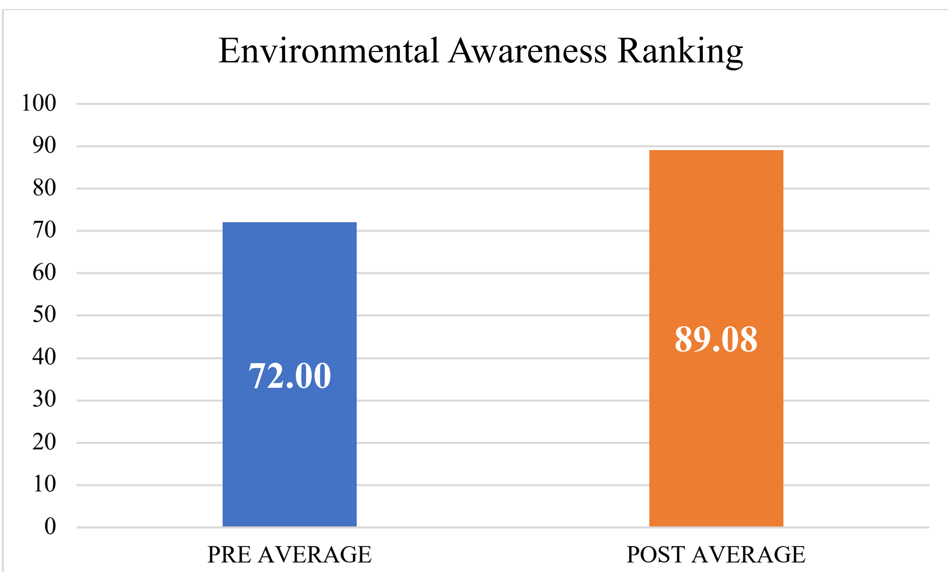


Figure 0-15: Participant Ranking of Their Environmental Awareness and Likelihood of Awareness Before and After the Event.
Participant ranking of their environmental awareness before the event (dark blue) and likelihood of environmental awareness after the event (orange). Responses were recorded from a scale of 0%-100% with higher numbers representing higher levels of awareness.

These results further complement and support the findings of the previously discussed studies by Stapleton et al. (2022) and Ardoin et al. (2020), while also expanding on others. In 2009, Bell et al. published a study highlighting the importance of informal settings in developing interest and capacity for environmental stewardship, concluding that community-based organizations enhance public understanding and engagement with environmental issues. This aligns with Baierl et al. (2022), who found that environmental outreach not only promotes significant gains in environmental knowledge and attitudes but also demonstrates that outdoor learning can foster long-term pro-environmental behavior. Collectively, these studies underscore the transformative potential of community-based and informal educational settings in cultivating environmental awareness and stewardship across varied demographics.

In regard to satisfaction, 87% of post-event respondents were extremely satisfied with the event, while 13% were somewhat satisfied (Figure 16A). No differences were observed between male ($M=5.00$, $SD=0.00$) or females ($M=4.86$, $SD=.36$, $p=.60$), nor participants who identified as White ($M=4.90$, $SD=.32$), Black or African American ($M=4.80$, $SD=.45$), nor other ($M=5.00$); $p=.83$. However, Kruskal-Wallis test found differences between participants' whose high education is a high school diploma or GED ($M=4.00$), some college but no degree ($M=4.83$, $SD=.41$), bachelor's degree ($M=5.00$, $SD=0.00$), or graduate degree ($M=5.00$, $SD=0.0$); $p=.05$. However, the only significant difference observed was between high school diploma or GED ($M=4.00$) a graduate degree ($M=5.00$, $SD=0.0$); $p=.05$. Lastly, no differences were observed between those who had experience studying or working in a field of environmental science or sustainability ($M=5.00$, $SD=0.00$), and those who did not ($M=4.86$, $SD=.36$); $p=.60$.

The results of our study indicate a strong consensus among participants regarding the relevance and usefulness of the event's content to their daily lives. Specifically, 81% of respondents stated they extremely agree that the content was relevant, while the remaining 19% agreed (Figure 16B). This high level of agreement underscores the pivotal role that relevant learning plays in enhancing understanding and engagement. Previous research has consistently demonstrated that when educational content is perceived as relevant, it significantly boosts learners' motivation and retention of information. For instance, Willis (2007) emphasized that relevance in educational content can enhance students' engagement and cognitive processing, leading to deeper understanding and long-term retention. Similarly, Akınoğlu and Tandoğan (2007) found that hands-on and relevant learning experiences correlate with higher student achievement and improved critical thinking skills.

Along with relevance, equity plays a crucial role in establishing effective community events that enhance learning and promote sustainable behaviors and environmental awareness (Martin, n.d.). In our study, 87% of respondents strongly agreed and 13% agreed that the event provided equitable resources and materials, enabling all participants to learn, interact, and engage regardless of their personal backgrounds (Figure 16C). This finding highlights the importance of designing community events that are accessible and inclusive, ensuring that everyone can benefit from the educational opportunities provided.

The lack of observed differences in responses between male ($M=5.00$, $SD=0.00$) and female participants ($M=4.86$, $SD=.36$, $p=.60$), as well as among various racial and educational groups, further reinforces the event's success in delivering equitable education. The Kruskal-Wallis test reported no significant differences in perceptions of equity among participants identifying as

White (M=4.80, SD=.42), Black or African American (M=5.00, SD=0.00), or other (M=5.00); p=.53. Additionally, educational background did not influence perceptions of equity, with similar responses from those with a high school diploma or GED (M=5.00), some college but no degree (M=4.67, SD=.52), a bachelor's degree (M=4.75, SD=.50), or a graduate degree (M=5.00, SD=0.00); p=.05.Moreover, participants with and without prior experience in environmental science or sustainability reported similar levels of agreement regarding the event's equity (experienced: M=5.00, SD=0.00; inexperienced: M=4.86, SD=0.36; p=.60). This indicates that the event was designed effectively to cater to varying levels of prior knowledge and expertise, which is crucial for engaging a diverse audience.

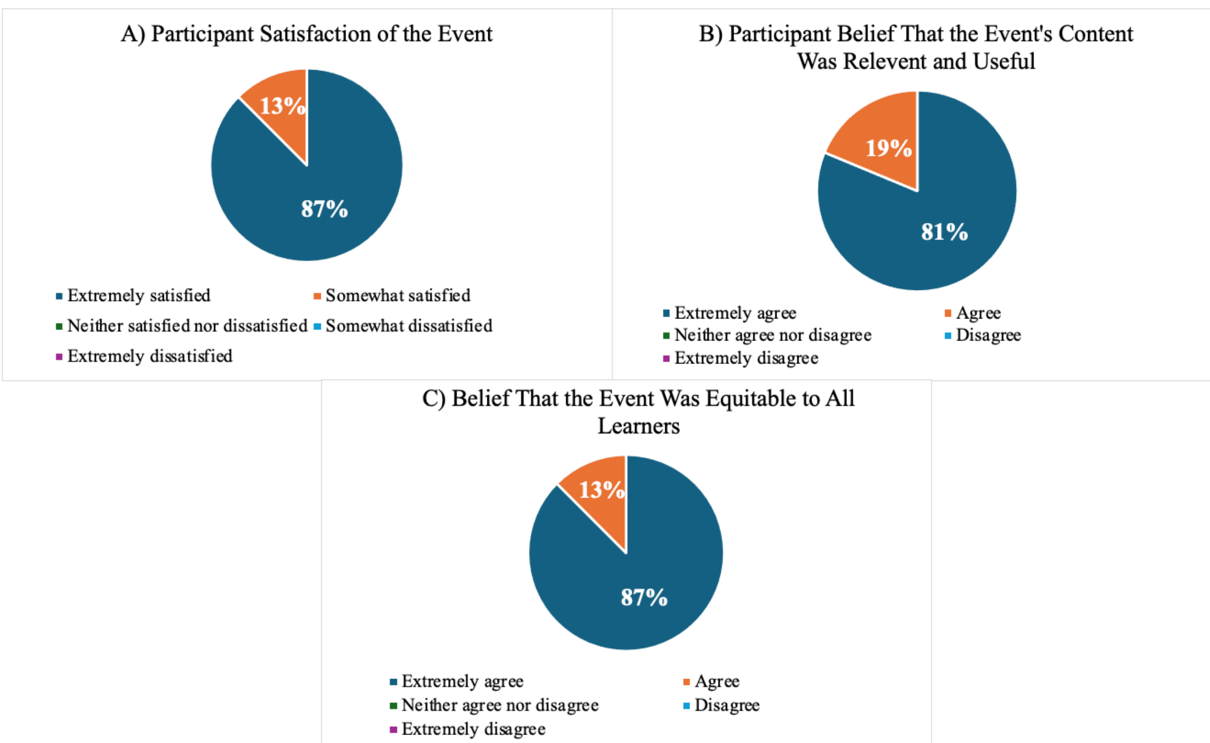


Figure 0-16: Participant Satisfaction Of The Event (A), Belief In The Event's Relevance (B) And Equity (C).

Overall, 81% of respondents stated definitely yes, that the event can help increase interest in environmental science, 13% stated probably yes, and 6% states might or might not (Figure 17A).

No differences were observed between male (M=5.0, SD=0.00) or females (M=4.71, SD=0.00, p=.53). Kruskal-Wallis test resulted in no differences between participants who identified as White (M=4.60, SD=.70), Black or African American (M=5.00, SD=0.00), nor other (M=5.00, p=.36), nor differences between participants' whose high education is a high school diploma or GED (M=5.00), some college but no degree (M=4.67, SD=.52), bachelor's degree (M=4.50, SD=1.00), or graduate degree (M=5.00, SD=0.00, p=.56). Lastly, no differences were observed between those who had experience studying or working in a field of environmental science or sustainability (M=5.00, SD=0.00), and those who did not (M=4.86, SD=.36); p=.53.

Furthermore, 94% of respondents stated definitely yes, that the event can help support environmental learning materials taught in school, and 6% stated probably yes (Figure 17B). No differences were observed between male (M=5.00, SD=0.00) or females (M=4.86, SD=.36, p=.60). Kruskal-Wallis test resulted in no statistically significant differences between participants who identified as White (M=4.80, SD=.42), Black or African American (M=5.00, SD=0.00), nor other (M=5.00); p=53. Additionally, no differences were observed between participants' whose high education is a high school diploma or GED (M=5.00), some college but no degree (M=4.83, SD=.41), bachelor's degree (M=4.75, SD=.50), or graduate degree (M=5.00, SD=0.00); p=.05. Lastly, no differences were observed between those who had experience studying or working in a field of environmental science or sustainability (M=5.00, SD=0.00), and those who did not (M=4.86, SD=.36); p=.60.

According Kennedy & Odell (2014) the cultivation of a hands-on educational environment, led by local environmental scientists is pivotal in shaping students' career aspirations; allowing the next-generation to interact and form personal connections with active researchers cultivates inspiration and a shared sense of importance of the subjects being discussed. Furthermore, our results complement the work of Martin-Hansen, (2018) who state that community engagement activities are shown to improve students' sense of belonging and interest in pursuing scientific careers. The consistent positive responses across different demographics and educational backgrounds suggest that the event effectively promotes interest and supports environmental education universally. The absence of significant differences based on gender, race, education level, or prior experience in environmental science underscores the event's broad appeal and inclusivity.

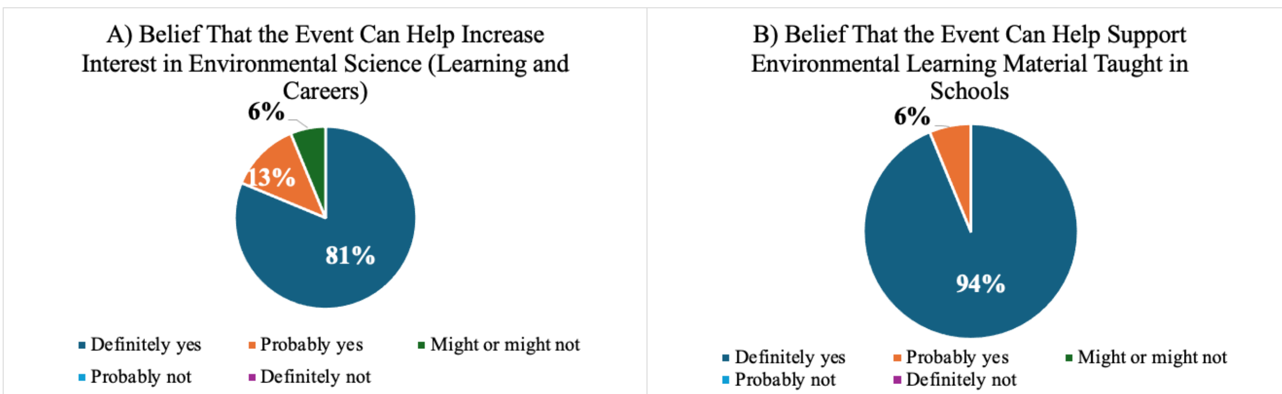


Figure 0-17:Participants' Belief That The Event Can Help Increase Interest In Environmental Science (A) And Can Help Support Material Taught In School (B).

Open response results highlight the success in engagement, variety of material, and satisfaction of the event. One respondent stated "[the event] exceeded my expectations. All of the stations were so well presented, and my [child] was engaged with all of them". Another shared, "there was a variety of relevant topics that were accessible to all age groups!". In regard to suggestions participants mentioned expanding the outreach and hosting more events; "take this event on the road, job well done". Qualitative resources highlight the impact of the event and the public's desire to integrate more community outreach events centered around sustainability.

1.52 Conclusion

The analysis of survey responses from the 2023 and 2024 environmental education events reveals that participants found the events highly informative and impactful, enhancing their understanding and practice of environmental awareness and sustainability. In 2023, the majority of respondents strongly agreed that the event improved their understanding of composting (56%), recycling and proper waste disposal (89%), and upcycling (78%), indicating effective communication of these topics. However, only 22% strongly agreed that they understood the carbon cycle, highlighting a need for better explanation or engagement on this topic.

By 2024, significant improvements were observed in participants' understanding of specific environmental concepts. Understanding of green energy ($p=.03$), composting ($p=.005$), and upcycling ($p=.02$) showed notable increases from before to after the event. These results suggest that the event's educational materials and activities were effective in enhancing participants' knowledge. Other subjects did not show significant differences, which underscores participants' prior interest and understanding of environmental subjects and highlights the need to engage more diverse and less exposed community members. Furthermore, no differences in understanding or importance of the subjects were found among different demographic groups, indicating the equity of the learning materials provided.

The high average understanding ($M=4.26$) prior to the event may have contributed to the significant changes observed in behavior, considering the Stages of Change or Readiness for Change Theory. With participants already understanding the subjects and considering them important, behavior change was more likely to occur. The results showed that participants were more likely to practice recycling ($p<.001$), proper waste disposal ($p=.01$), composting ($p=.002$), minimizing energy consumption ($p<.001$), considering energy sources ($p<.001$), upcycling (p<.001), planting native species (p=.009), and thinking about how their environmental practices impact local wildlife (p=.003). Similar to the understanding results, no significant differences were found among demographic groups.

The hands-on learning activities provided at the event, aligned with Social Cognitive Theory, likely built participants' confidence and belief in their ability to change towards a more sustainable lifestyle. Surrounding participants with others interested in learning more, as suggested by Social Influence Theory, further supported this confidence-building process. This environment of active learning and social reinforcement created a supportive atmosphere that promoted behavior change.

Overall, the results showed significant increases in environmental awareness and sustainable practices, underscoring the event's impact even among a population with a good pre-existing understanding of the concepts. Participants reported high satisfaction with the event, finding it relevant and useful to their lives, and equitable to all learners. The only significant difference in satisfaction was found among educational groups, with participants holding a high school diploma or GED reporting slightly lower satisfaction compared to those with graduate degrees (p=.05). This discrepancy may be due to the small sample size of individuals with the highest level of education being a high school diploma or GED.

For both 2023 and 2024, suggestions for improvement included better advertising and increased outreach efforts, indicating a desire for broader community engagement and more frequent events. These findings highlight the impact and significance of outreach events for promoting sustainability and environmental awareness. Additional efforts and studies are needed to engage community members who may not initially be environmentally aware. Future research should also consider longitudinal studies to investigate the long-term effects of such events on behavior and mindset change.

1.53 Literature Cited

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Cultivation Curiosity: The Impact of Mentorship and Family Outreach on Minority Student's Interest in Science

1.54 Abstract

The lack of diversity in scientific fields continues to hinder sustainable development, as underrepresentation of minority groups limits the range of perspectives and ideas in scientific innovation. Alabama faces many challenges towards sustainable development including racial and educational inequities as well as environmental injustices. The importance of outreach and mentorship in promoting diversity in STEM and addressing sustainable development in Alabama cannot be overstated. This study evaluates the impact of YPiT (Young Professionals in Training), a minority mentorship and outreach group in Auburn, Alabama, on promoting scientific interests amongst students. The objective of this work was to evaluate the perspectives of educational professionals, participating students and parents on this program. Survey data from educational professionals revealed a broad consensus on the program's potential to enhance students' science proficiency, interest in science-based careers, and college attendance. However, logistical challenges and unfamiliarity with the program were noted barriers. Feedback from students and guardians underscored the importance of representation and mentorship, highlighting significant improvements in students' confidence, academic performance, and career aspirations. This study illustrates how exposure to diverse role models in STEM can reshape minority students' perceptions of belonging, thereby fostering a more inclusive scientific community.

Keywords: Sustainability, STEM Education, Mentorship, Equity

1.55 Introduction and Background:

Sustainability goes beyond environmental conservation, encompassing the balance between social equity and economic principals to create a holistic approach to lasting prosperity (Sachs et al., 2022; U.S Environmental Protection Agency, 2023).Alabama, who ranks 45th in sustainable development in the United States, faces several challenges including racial equality in education, with an overall score of 28.0% in "leave no one behind" (Lynch & Sachs, 2021). Sustainability is often covered within state science curriculum standards (Alabama Learning Exchange, n.d), where only 37% of students in Alabama have achieved proficiency (Alabama STEM Council, 2022). In 2022, Black and African American students recorded the lowest rates of science proficiency, college career readiness, and overall academic achievement within the state (Alabama Department of Education, 2022).

The inequity of education, paired with the lack of lack of sustainable development within the state places underrepresented populations at enhanced environmental risks. Previous studies have found that minority populations are more likely to experience environmental injustices, with socioeconomic factors, geographic areas, and predicted environmental challenges due to climate change exacerbate these issues (Devlin et al., 2014; Holifield, 2023). A synthesis by Gutierrez & LePrevost (2016) found that minorities in the Southeast were more likely to have health complications due climate change, including greater likelihoods of asthma, cancer, heart complications, development, neurological disorders, vector-borne diseases, waterborne diseases and mortality. In order to ensure long term prosperity, it is essential to consider all populations, and to diversify the field of science, technology, engineering, and mathematics (STEM) (Balanay & Richards, 2022; Swartz et al., 2019). In 2021, only 15% of the United States STEM workforce identified as Hispanic, 10% Asian, 9% Black and less than 1% identified as American Indians and Alaska Native (National Science Foundation, 2023). Having a more diverse STEM workforce, and population of individuals who are proficient in science and sustainability enhances development by expanding the perspectives of research and promotes the investigation and consideration of subjects that are often underrepresented (Balanay & Richards, 2022). Therefore, it critical to create opportunities to enhance representation in the field to ensure underrepresented perspectives and voices can be heard and considered in emerging developments.

According to Sheffield et al. (2021), promoting a diverse representation of scientists in classrooms is an important step towards turning scientific disciplines into more inclusive communities. In 2020, of all science and engineering college graduates, only 9% identified as Black, 0.4% identified as Indigenous and 16% identified as Hispanic (Josh Trapani & Katherine Hale, 2022). Previous studies have found that many minority students feel as though “they do not belong” in STEM due to the lack of minority representation within the field (Dutt, 2020; Yacoubian et al., 2017). Furthermore, these same studies found that the of a sense of “not belonging” from minority students has attributed to a decrease of interest and pursuit of STEM careers. However, when minority students were introduced to minority professional scientists their preconceptions of “who belongs in science” broadened (Sheffield et al., 2021). Overall, the lack of inclusive representation within STEM fields skews interpretations of who “belongs” in science. These findings complementwhat is known of the Social Influence Theory, which centers around the belief that individuals’ actions and beliefs are influenced by those they see or surround themselves with. Developed by Herbert Kelman, this theory explains that individuals' behaviors are influenced through compliance (appearing to agree with others), identification (conforming to build relationships), and internalization (adopting and accepting behavior as it aligns with personal values) (Kelman, 1958). To promote diversity within the field of STEM it is critical to develop better representation of minorities to influence and inspire younger generations.

Christian et al. (2018) who studied the perspectives and experiences of high school students towards the environment in the state of Alabama, found that there is a need to design broad science literacy and outreach programs in order to motivate students, enhance knowledge and significantly increase awareness and involvement of students from minority communities in various fields of science (Christian et al., 2018). Additional work has backed the conclusions of Christian et al. (2018) by investigating the impact of outreach, specifically mentorship, in addressing these challenges. To begin, the Centre for Addiction and Mental Health and Big Brothers Big Sisters Canada, found that mentored boys are twice as likely to believe that school is "fun" and that doing well academically is "important" (Centre for Addiction and Mental Health, 2013). Moreover, DuBois et al. (2011), who conducted a study on 73 individual mentorship programs to study their effects on children's social, behavioral, emotional, and academic well-being, found that mentorship programs have a positive effect on the variables studied, including academic success. Additionally, a similar study conducted by Rodríguez-Planas (2012), found that there are positive long-term effects of mentorship programs on students as well. Results of this study concluded that students who participated in mentorship programs had a higher chance of graduating high school and pursuing post-secondary education. In conclusion, these studies collectively highlight the critical role of mentorship and outreach programs in fostering science literacy, enhancing academic engagement, and promoting long-term educational success among minority students.

1.56 Objectives and Hypothesis:

In partnership with a local mentorship and outreach group in the Auburn, AL, the Young Professionals In Training (YPiT), the aim of this study was to understand how a minority-focused mentorship group impacts student's educational achievement and post-secondary interest in STEM. YPiT seeks to provide support to minority students within Lee, Macon and Chambers counties. Resources provided by the program include mentorship, tutoring, dual enrollment, scholarships and pipelines to Auburn university and monthly parent and student workshops. During the 2023-2024 academic year, the central theme of the program was STEM career and educational exploration. We hypothesize that outreach and minority representation in the field of STEM can increase student interest and participation in science.

1.57 Methodology:

1.57.1 Studying the Attitudes of Educational Professionals:

1.57.1.1 Survey Development and Recruitment:

A survey was developed to measure to attitudes of educational professionals, located in participating counties, on YPiT's potential to promote minority STEM education and interests in the field. The survey began with several background questions, regarding the position and location of the respondent. Additionally, the survey featured Likert-scale questions evaluating the programs potential to promote STEM learning, as well as the likelihood of these professionals to promote the program after learning about it. Prior to distribution the survey was approved by the Institutional Review Board (#22-416 EX 2211); survey review and approval is described in section 4.3.

The emails of secondary science teachers, STEM resource specialists, councilors, and career preparation coaches, were collected from public school websites. Only schools that were located in counties that participated in YPiT were considered; districts included: Auburn City Schools, Opelika City Schools, Lee County Schools, Macon County Schools, and Chambers County Schools. Included in the email was a flyer with information about the program, including the resources they provide, and a link to the survey. Educational professionals survey questions are listed below.

Educational Professionals Survey Questions:

1) What school or organization are you a part of? [open response]
2) What is your position? [open response]
3) Is this the first time you have heard about Young Professionals in Training?
   a) Yes [value: 1]
   b) No [value: 2]
4) Young Professionals in Training offers participants free tutoring, mentorship, automatic enrollment at Auburn University, and scholarship opportunities. Mentors and Tutors are Auburn University faculty, staff, and students. For example, if a student needed help with science, they could work with a real science researcher, professional or student at the university! Given this, and based on your opinion, how likely is it that the participants in this program will experience the following: [Likert scale: 5-Extremely likely, 4-Somewhat likely, 3-Neither likely nor unlikely, 2-Somewhat unlikely, 1-Extremely unlikely]
   i) An increase in science proficiency
   ii) An increase in interest in science-based professions
   iii) An increase in interest in attending college
   iv) Increased performance in school

5) How likely are you to recommend this program to students? [Likert scale: 5-Extremely likely, 4-Somewhat likely, 3-Somewhat unlikely, 2-Extremely unlikely]
6) Why might you NOT recommend this program [open response]

1.57.1.2 Survey Assessment:

The results of the survey were evaluated using descriptive statistics, as well as comparisons between groups (position and district) using a one-way ANOVA. In the event any ANOVA results violated the homogeneity of variance, a non-parametric Kruskal-Wallis test was performed. Cronbach's Alpha was used to evaluate the internal consistency of a survey items that utilized multiple Likert-scale questions. Data assessment of these tests is described in section 4.5.

1.57.2 Studying the Attitudes of Program Participants:

1.57.2.1 Interview Development:

Demographic surveys and semi-structured interviews were developed to gather background information on participants (students and their guardians), and to further understand their attitudes towards the programs impact of STEM education and career exploration, as well as the importance of representation in mentorship relationships. Prior to distribution, surveys, interview questions and procedure was approved by the IRB (#24-680 EP 2402).

1.57.2.2 Student Participant Interview Questions and Assessment

Student demographic questions included children's age, grade, school district, race, and gender. Student surveys, and consent documentation were completed by their parents. After completing the demographic surveys and signing consent forms, guardians were sent an availability poll to schedule their Zoom interview. Once dates were selected, participants were interviewed on a private Zoom meeting with their guardians present. The Zoom interviews were recorded for later transcription. Interview questions included themes of motivation and initial engagement, support and influence of mentorship, importance of representation and shared identities with mentors, academic and professional development and feedback on the program. A list of student demographic, and interview questions can be seen below. Transcriptions were evaluated for themed responses and trends. Furthermore, all identifying information was removed following transcriptions to ensure confidentiality of each participant. Prior to implementation, the interview questions and methodology were evaluated and approved by the Institutional Review Board.

Student Demographic Questions:

1) What is your child's name?
2) How old is your child?
3) What grade is your child in?
4) What school does your child go to?
5) Choose one or more races that you consider your child to be
    a) White or Caucasian
    b) Black or African American
    c) American Indian/Native American or Alaska Native
    d) Asian
    e) Native Hawaiian or Other Pacific Islander
    f) Other
    g) Prefer not to say
6) How would your child describe themselves?
    a) Male

b) Female

c) Non-binary / third gender

d) Prefer to self-describe

e) Prefer not to say

Student Interview Questions:

1. What made you join YPiT?
2. What are some of the support services YPiT has provided for you?
3. How would you best describe the relationship you have with your mentor(s) at YPiT?
4. Who are some of the other influential people in your life? How is your mentor different than
5. these people?
6. How important is it to you to have a mentor that you can identify with, whether that be by a
7. sharing a similar ethnicity, racial background, cultural background and/or gender as you?
8. How would you describe yourself as a student?
9. How has YPiT impacted your experience at school?
10. How has YPiT impacted your confidence in school?
11. Has YPiT helped you in science classes and subjects?
12. Are you interested in attending college?
13. How has YPiT impacted your interest in college?
14. What do you want to be when you grow up?
15. Has YPiT impacted your career interests?
16. Do you have any interests in science related fields/careers?

17. What science related subject has YPiT taught you about?
18. What is your favorite part about the program?
19. Any suggestions on how to improve the program?

1.57.2.3 Guardian Participant Interview Questions and Assessment

Guardian surveys included questions on their race, gender, educational background, county of residence, relationship to the child and years of involvement with the program. After completing the demographic survey and signing consent forms, participants were sent an availability poll to schedule their Zoom interview. Once dates were selected, participants were interviewed on a private Zoom meeting, which was recorded for transcription. Interview questions included the same themes present in the student interviews. A list of guardian demographic, and interview questions can be seen below. Transcriptions were evaluated for themed responses and trends, additionally, all identifying information was removed following to ensure confidentiality of each participant. Prior to implementation, the interview questions and methodology were evaluated and approved by the Institutional Review Board.

Demographic Questions

1) What is your name? (your name will not be used in the study, but will help Carly accurately identify responses in the interview)
2) Choose one or more races that you consider yourself to be
   a) White or Caucasian
   b) Black or African American
   c) American Indian/Native American or Alaska Native
   d) Asian
   e) Native Hawaiian or Other Pacific Islander

f) Other

3) Prefer not to say

4) How would you describe yourself?

a) Male

b) Female

c) Non-binary / third gender

d) Prefer to self-describe

e) Prefer not to say

5) What is the highest level of education you have completed? (*Qualtrics certified question)

a) Some high school or less.

b) High school diploma or GED.

c) Some college, but no degree.

d) Associates or technical degree.

e) Bachelor's degree.

f) Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.).

g) Prefer not to say.

6) Which county are you from?

a) Macon

b) Lee

c) Chambers

d) Other

7) How would you best describe your relationship to the child? (i.e. mother, father, aunt, grandparent etc.)

8) How many years have you been involved with YPiT?

Guardian Interview Questions:

1. What made you join YPiT?
2. What are some of the support services YPiT has provided for your child?
3. What are some of the support services YPiT has provided for you?
4. How do you feel the YPiT mentors impact your child's life?
5. In your opinion, how is mentorship different than the other influences in their life, such as their
6. teachers/family/friends?
7. Historically, science and academia has held a lack of diversity in the field. Previous studies have
8. shown that some students gain interest in certain fields when they can identify with other in the
9. field. To this end, how important is it to you that your child has a mentor that they can identify
10. with, whether that be by sharing a similar ethnicity, race, culture, and/or gender?
11. How has YPiT impacted your confidence as a parent/caregiver?
12. How has YPiT impacted your confidence as a learner?
13. How has YPiT impacted your child's education?
14. How has YPiT impacted your child's confidence in school and learning?
15. How has YPiT influenced your child's understanding of science/scientific concepts?
16. How has YPiT influenced your child's interest in science/scientific concepts?
17. How has YPiT impacted your child's post-secondary education plans?

18. How has YPiT impacted your child's interest in careers?

19. What is your favorite part about the program?

20. Any suggestions on how to improve the program?

1.58 Results:

1.58.1 Educational Professionals Survey Results:

Overall, 119 educational professionals were contacted and 44 responded (37% response rate). Of the respondents, 34% were located in Lee County Schools, 32% were from Chambers County Schools, 25% from Auburn City Schools, 5% from Macon County and 4% from Opelika City Schools (Figure 1B). Additionally, 33 of respondents were teachers, two were career coaches, and nine were councilors (Figure 1 A).

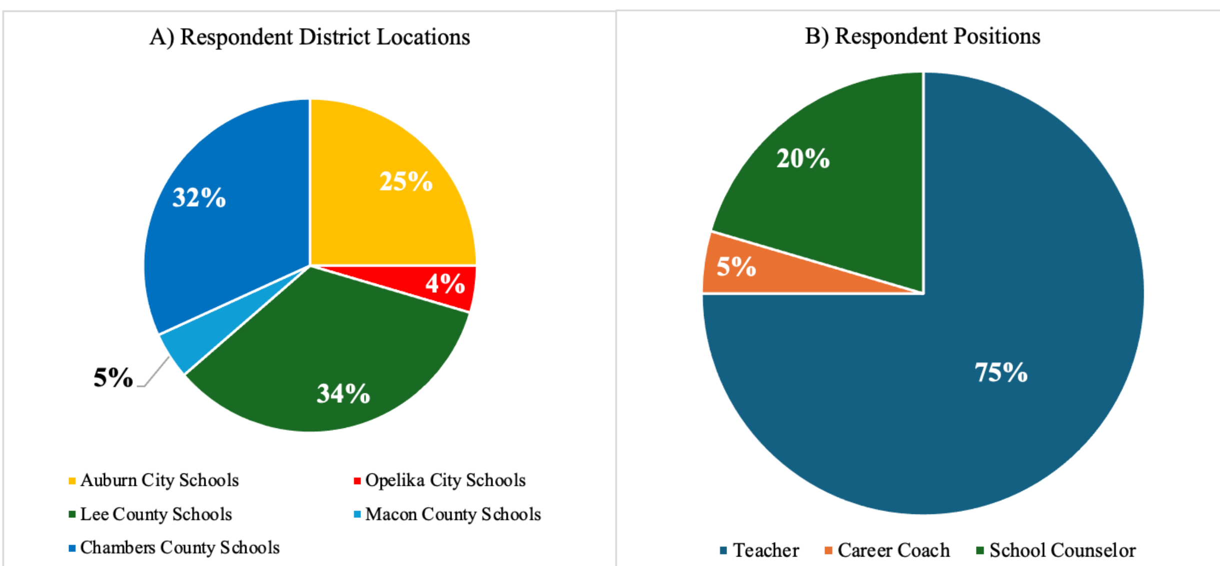

Figure 0-1: District Locations Of Each Respondent (A) And Their Position At Their School (B).

Internal consistency was found amongst question four, which featured questions related to the belief that YPiT can increase academic performance and post-secondary exploration (α =.76). Positive responses were found regarding educational professionals' belief that YPiT can increase students' science proficiency, with 66% stating extremely likely, 32% somewhat likely and 2% extremely unlikely (Figure 2A). A Kruskal-Wallis assessment, resulted in no significant differences in responses between teachers (M=4.70, SD=.467), councilors (M=4.22, SD=1.30), career coaches (M=4.50, SD=.707); p=.566. Using the same testing method, no significant differences in this response were observed between Auburn City Schools (M=4.55, SD=.522), Opelika City School (M=2.50, SD=2.12), Lee County Schools (M=4.67, SD=.488), Macon County Schools (M=4.50, SD=.707), or Chambers County Schools (M= 4.86, SD=.363); p=.068. These findings complementprevious studies which have found that mentoring has enhanced students science self-efficacy and identity within the field (National Academies of Sciences, Engineering, and Medicine; Policy and Global Affairs; Board on Higher Education and Workforce; Committee on Effective Mentoring in STEMM, 2019).

Similarly, 55% of respondents stated that it was extremely likely that YPiT can increase interest in science-based professions; 41% stated somewhat likely, 2% neither likely or unlikely, and 2% extremely unlikely (Figure 2B). ANOVA results found no significant differences amongst the responses of teachers (M=4.52, SD=.566), councilors (M=4.11, SD=1.27), career coaches (M=5.00, SD=0.00); p=.219. Additionally, a Kruskal-Wallis assessment resulted in no significant differences between Auburn City Schools (M=4.27, SD=.647), Opelika City Schools (M=3.00, SD=2.83), Lee County Schools (M=4.60, SD=.507), Macon County Schools (M=4.50, SD=.707), and Chambers County Schools (M= 4.64, SD=.497); p=.547. These responses are supported by previous work including that by Byars-Winston et al. (2015) and Estrada et al. (2018) who found that mentoring influences scientific identity by increasing student interest and confidence in scientific field. Additionally, these studies highlight the opportunities and resources fostered by mentoring relationships which promote career exploration

Overall, 64% stated it was extremely likely that YPIT can increase interest in attending college, and 36% stated somewhat likely (Figure 2C). No significant differences were observed following a Kruskal-Wallis assessment between teachers (M=4.55, SD=.564), councilors (M=4.67, SD=.500), and career coaches (M=5.00, SD=0.00);p=. 548. Additionally, using the same statistical test, no differences were observed between Auburn City Schools (M=4.45, SD=.522), Opelika City Schools (M=5.00, SD=0.00), Lee County Schools (M=4.53, SD=.640), Macon County Schools (M=4.50, SD=.707), and Chambers County Schools (M= 4.71, SD=.469); p=.563. These responses are supported by findings from Rodríguez-Planas (2012) who found that students involved in programs similar to YPiT obtained their high school diplomas earlier and were more likely to attend postsecondary education. Similarly, Kraft et al. (2021) found that mentored students were more likely to attain more schooling.

Lastly, 57% of respondents stated that they belief that YPiT is extremely likely to increase performance in schools, and 41% stated somewhat likely, while 2% stated neither likely nor or likely (Figure 2D). An ANOVA analysis found no significant differences between teachers (M=4.64, SD=.489), councilors (M=4.22, SD=.667), career coaches (M=4.50, SD=.707); p=.131. However, a Kruskal-Wallis assessment found significant differences amongst responses from Auburn City Schools (M=4.45, SD=.522), Opelika City Schools (M=4.00, SD=0.00), Lee County Schools (M=4.53, SD=.516), Macon County Schools (M=3.50, SD=.707), and Chambers County Schools (M= 4.86, SD=.363); p=.017. The significant differences observed were between Macon and Chambers, and Chambers and Opelika, with Chambers hosting higher averages in both comparisons. While this difference may be due to differing sample sizes, additional research is needed to definitively understand this discrepancy. However, overall, these results complement previous mentorship studies on academic achievement. A 2022 national survey reported that 88% of teachers reported that mentored students observed positive changes in academic performance (Gradient Learning Poll, 2022). Additionally, Kraft et al., (2021) found that mentored students earned higher grades, while the Centre for Addiction and Mental Health (2013) stated that mentored students felt that doing well academically is “important”.

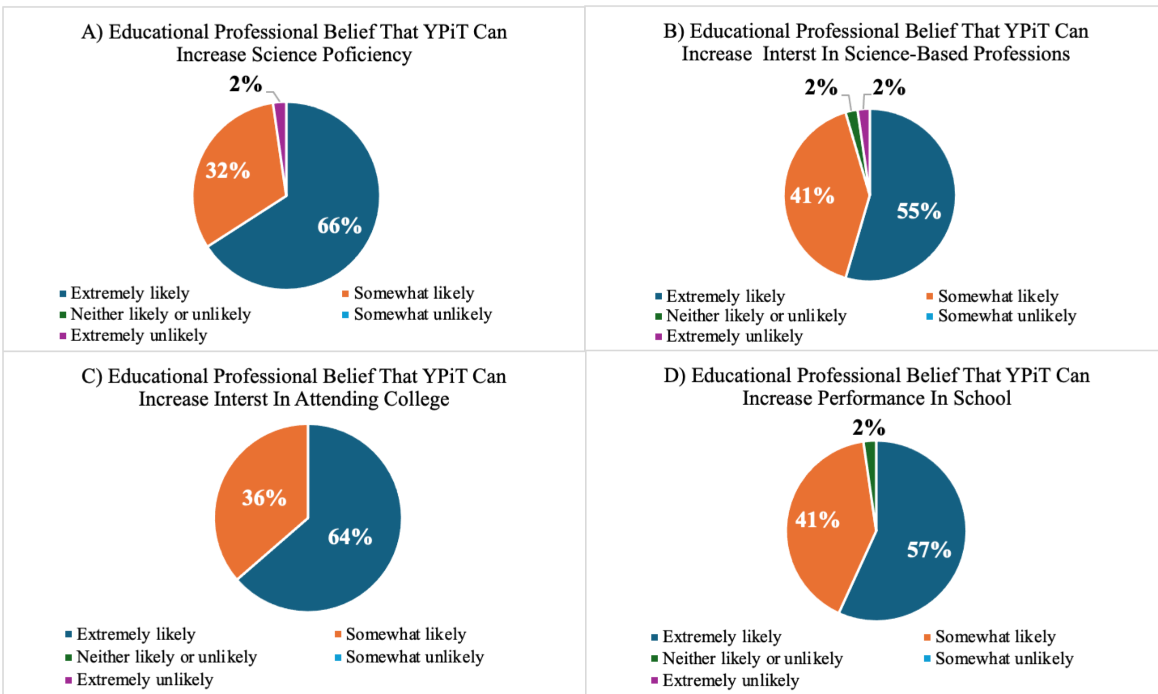

Figure 0-2: Educational Professionals Belief In The Program’s Impact of Student Achievement and College and Career Exploration

Results found that for 86% of respondents, this was there first time learning about the program, whereas for 14% they had heard of the program prior (Figure 3A). An ANOVA analysis found no significant difference in this response between teachers (M=1.12, SD=.331), councilors (M=1.11, SD=.333), career coaches (M=1.50, SD=.707); p=.323. Additionally, a Kruskal-Wallis assessment sound no significant differences between Auburn City Schools (M=1.27, SD=.467), Opelika City Schools (M=1.50, SD=.707), Lee County Schools (M=1.07, SD=.258), Macon County Schools (M=1.00, SD=0.00), and Chambers County Schools (M=

1.07, SD=.267); p=.258. While for most this was their first-time hearing about the program, 98% of respondents indicated that they were likely to recommend the program (64% extremely likely, 34% somewhat likely), only one respondent indicated extremely unlikely (Figure 3B). A Kruskal-Wallis assessment found no significant differences between the responses of teachers (M=4.46, SD=.489), councilors (M=4.22, SD=1.30), career coaches (M=5.00, SD=0.00); p=.316. Furthermore, an ANOVA analysis found no significant differences between Auburn City Schools (M=4.36, SD=.505), Opelika City Schools (M=4.50, SD=.707), Lee County Schools (M=4.47, SD=1.06), Macon County Schools (M=4.50, SD=.707), and Chambers County Schools (M=4.86, SD=.363); p=.51. These results are again complemented by the findings of a 2022 national survey that found that 95% of teachers believe every student can benefit from a mentor (Gradient Learning Poll, 2022).

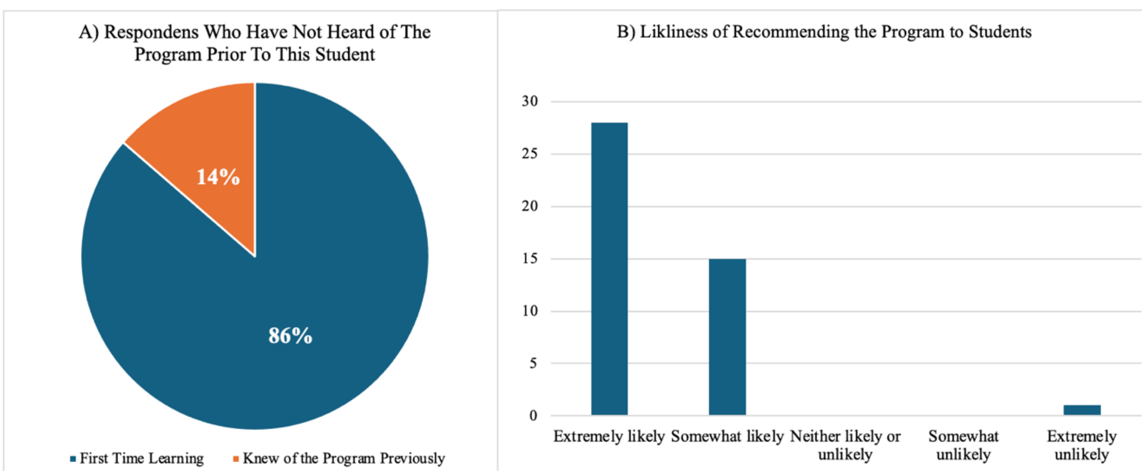

Figure 0-3: Educational Professionals Prior Knowledge of the Program (A) and Likeliness of Recommending It (B)

Educational professionals identified several barriers to recommending the local mentorship program. The primary concerns include the challenge of motivating high school students, the program's selective targeting, and logistical and accessibility issues. One respondent stated, "accessibility would be the main concern. [Our] school is located a good 30 minutes from Auburn and the best time to build those foundational skills in science/love for science/interest is when they are not old enough to drive.". Others expressed liability concerns and their lack of familiarity with the program. One participant stated, “I worry about recommending programs outside of [my district] because I don't want to be held responsible if something bad happens”. Another said, "[I am] just not familiar enough with the program to fully recommend it.". Others stated, “out of sight, out of mind! So much goes on in the day and if teachers are not constantly exposed to the many opportunities available-we forget!". These barriers highlight the need to advance visibility of outreach programs such as YPiT, and to advocate and establish more localized resources for areas in need.

Overall, educational professional survey responses highlighted positive belief and reception of the YPiT mentoring program. While these results are complimented and supported by previous research, they may also relate to personal experience. The Alabama Department of Education has established its own peer-mentorship program for teachers beginning in 2016 (Alabama Department of Education, 2017). This program requires all local education agencies to have a mentorship program in place to help support new educators in their systems. In 2022, an effectiveness report was published, reporting increased participating in the program and stating that 94% of the mentors and 97% of the mentees felt that the program effectively supported novice teachers (Alabama Department of Education, 2023). This experience likely reinforces their belief in the value of student mentorship programs, as they have seen firsthand the benefits of mentorship in their professional environment.

1.58.2 YPiT Student Results

In 2023-2024 the average student attendance of YPiT was 22; six students were signed up to participate in the study. Overall, all participants were identified by their guardians as Black or African American (Figure 4A), half were female, and the other half were male (Figure 4B).

Student participants ranged in age between 11-16 years old. One participant was in 5th grade, one in 7th, one in 8th, two in 9th and one 12th (Figure 4C). Furthermore, 67% of participants attended Auburn City Schools, 17% Opelika City Schools and 16% Macon County (Figure 4D).

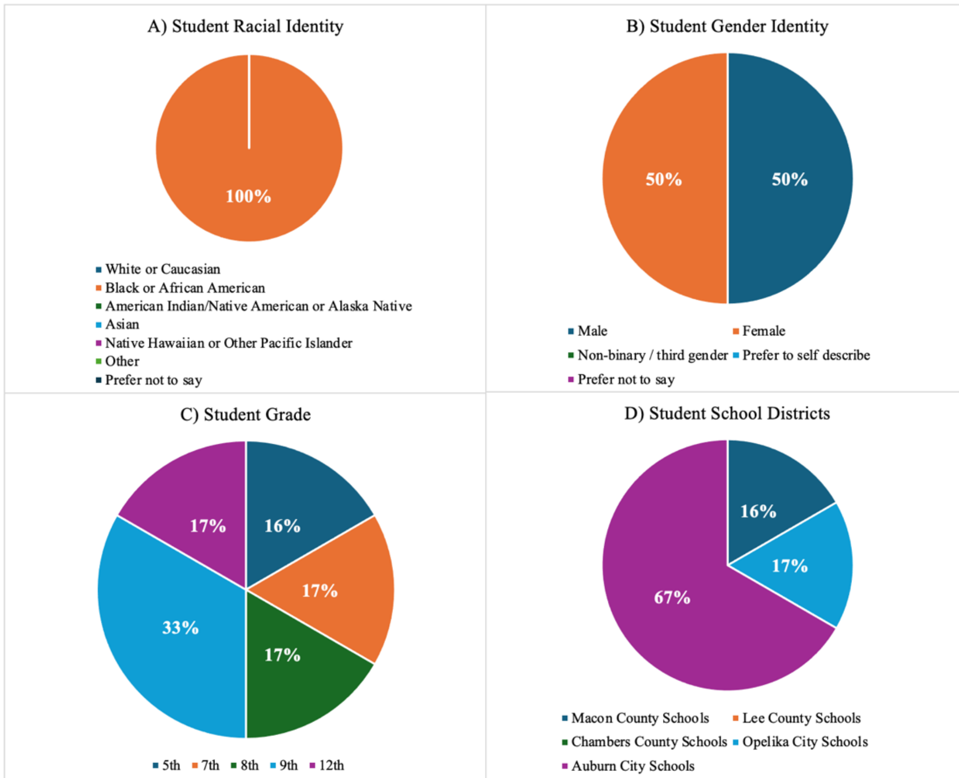

Figure 0-4: Visualization Of The Racial Identity (A), Gender Identity (B), Grade (C) And School District (D) Of Student Respondents.

1.58.2.1 Motivations and Initial Engagement

When asked about why they joined YPiT many student participants stated that their guardian signed them up, however some students comments on their willingness to attended due to their love of science. One student said, “I was really interested in learning about science”, another reflected “I didn’t really know why my mom signed us up for YPiT…but as we started to [participate in some of] the activities I said ‘okay, I like this, and I would look forward to doing it!’”. Lastly, one student reflected on their interest in engineering, and how the programs focus of STEM in the 2024 year was exciting and appealing. These results highlight the significance of Social Influence Theory in outreach attendance (Kelman, 1958), while also underscoring the limitations outreach programs face in reaching individuals who do not have a prior interest in the field (De Weger et al., 2018).

1.58.2.2 Support and Influence of Mentorship, and the Difference Between Mentors and Other Influences

When asked to reflect on the differences between a mentor and other influential figures in their lives, students described mentors as “non-judgmental”; that they were “more of a friend, [and] you can talk about anything”. Others stated that “the mentors are easy to talk” and that they “offer advice and try to help you”. Furthermore, students highlighted the comfort and “safe space” that a mentor provides, describing their relationship as “friendly”. One student noted that their mentor is “more of a friend, you can talk about anything”, another describes their relationship as “more like a family”. Another student expressed the impact on their confidence talking to others, stating “normally when I meet someone, I’m really shy, but [YPiT] has helped me open up to someone when I meet them”.

The characteristics highlighted by students complement findings of previous work which state that successful mentoring relationships are developed through reciprocity, mutual respect, personal connection, and shared values (Straus et al., 2013). Moreover, these findings are supported by the work of Jean Rhodes (2004) who suggests that the positive influence of mentoring is contingent feelings of trust, and empathy.

1.58.2.3 Importance of Representation and Shared Identities with Mentors

When asked about the importance of having a mentor with a similar background and identify as themselves students expressed the importance and comfort of this aspect. One stated, “See, [representation and a shared identity] is very important, and it makes you more comfortable to be around them”. Others stated that having shared identities makes the experience “more helpful, because they may have gone through the same situations as you and have help you with the things that you are going through”.

The significance of shared identities highlight the aforementioned essential characteristics presented by Straus et al. (2013) and Rhodes (2004); having a mentor they could culturally or racial identify allowed for increased empathy, trust and personal connection. Additionally, these responses are supported by findings from Martin & Fisher-Ari (2021) who state that having mentors of similar background provide a safe space and understanding.

1.58.2.4 Academic and Professional Development

As for the impact on their education and career interests, one student stated, “I am a good student, and I feel that YPiT has helped widen those areas of my knowledge and education”. Many commented on the increased confidence they had in themselves and the content their have learned, with one student stating, “YPiT has definitely helped me become more confident in my answers [and] helped me raise my hand in the air [at school]” and that learning science through YPIT “gives you a head start”. Students also shared their growth in academic achievement, with one student commenting on their increased standardized testing scores and another sharing that before YPiT they struggled in school, and now there are in Advanced Placement courses.

Another common theme was the robust exposure students have had regarding potential careers, one student stated, “[YPiT] gave me some options about what I can be when I grow up, or subjects that I really want to focus on more”. Many expressed that they were not sure what they would like to be when they grow up yet, but that YPiT has expanded or solidified certain areas of interest, with one student stating “[YPiT] showed me what I like and what I don’t like”.

Others commented specifically on STEM explorations stating “[YPiT] gave me more of a push to want to be an engineer” another said “[YPiT can impacted me a lot, I really would like to go into science when I go to college”. Overall, the program has increased student confidence, and interest in attending college.

The results of these responses are well supported by previous work including those of Kraft et al. (2021) and Rodríguez-Planas (2012), who found that mentored youth were more likely to graduate high school and further their education. Furthermore, mentorship programs have been known to offer expansive resources that promote career and educational exploration (National Academies of Sciences, Engineering, and Medicine; Policy and Global Affairs; Board on Higher Education and Workforce; Committee on Effective Mentoring in STEMM, 2019). Additionally, increased interest in science exploration and identity was also found by Atkins et al., (2020), Byars-Winston et al. (2015 and Estrada et al. (2018). Sheffield et al. (2021) explains that having diverse representation of scientists broaden perceptions of “who belongs in science”.

1.58.2.5 Feedback on the Program

As for feedback, many students expressed that the informal learning experiences provided by the program including field trips, and hands-on lessons were their favorite parts. Previous work has supported the impact of informal learning experienced by these students (Lin & Schunn, 2016), showcasing positive impacts on students’ attitudes and abilities in science education. However, many participants did not have comments for improvement or change, while a few mentioned the desire to meet more often; further highlighting the positive reception of the program and desire for increased involvement.

1.58.3 YPiT Guardian Results:

In 2023-2024 the average guardian attendance was 13; six signed up to participate in the study. All respondents identified at Black of African American (Figure 5A), female (Figure 5B), and as a mother of their child participant. Additionally, 83% of participants had graduate or professional degrees, and 17% had a high school diploma or GED (Figure 5C). The majority (83%) of participants reside in Lee County, while 17% reside in Macon (Figure 5D). Furthermore, the number of years involved in the program varied, with one participant being involved for three years, two for two years, and for three this was their first year (Figure 5E).

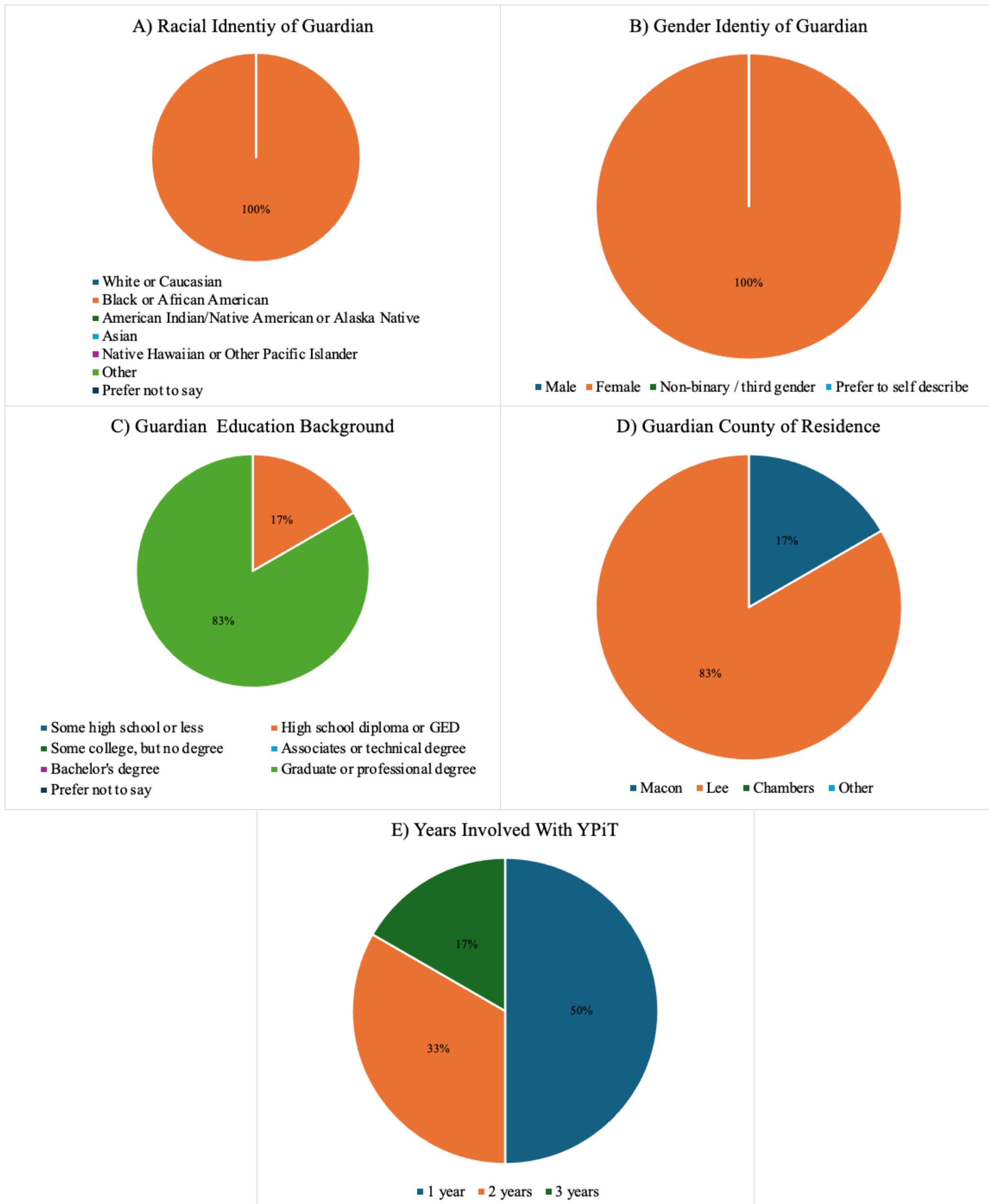

Figure 0-5: Visualization Of The Racial Identity (A), Gender Identity (B), Educational Background (C) County Or Residence (D), And Years Involved Within The Program (E) Of Guardian Respondents.

1.58.3.1 Motivations and Initial Engagement

When parents were asked about why they joined YPiT many highlighted the social opportunities to engage with children and families of similar backgrounds and aspirations. One participant stated, “I wanted to be in a community that had a lot of representation for people who looked like [my child],” another stated, “I wanted something for [my child] could have the opportunity to be social with other kids who are trying to do something good in their lives.” One participant shared how they just moved to the area and “needed to connect with other families.” Moreover, many participants highlighted the educational resources the program offered, stating “it was a good opportunity for [my child] to continue [their] growth in science and math.” Another participant stated that YPiT was a “a good opportunity for [my child] to get good mentorship with positive people, trying to help [my child] prepare for the future.” Lastly, many learned about the program through a friend who was either working for the program or were participating themselves.

Results from previous studies complement these responses. In 2011 Spencer et al., reported that modivations of parents who enrolled in mentorship programs included hope that mentors would serve as a positive role model and could provide opportunities to nurture a broader array of experiences and possibilities. Furthermore, parents’ general desire for representation is well supported, with studies showing that students who have been exposed to increased diversity within STEM fields were more likely to be interested and engaged (Grimshaw, 2016; Sheffield et al., 2021; Spencer et al., 2011).

1.58.3.2 Support and Influence of Mentorship

YPiT resources highlighted by guardians included mentorship, parent support groups, career exploration opportunities, and exposure to additional resources including disability advocation, educational opportunities and community events. Additionally, participants highlighted the “safe space” provided by YPiT and how their representation and openness has helped inspire students and develop confidence in their daily lives. One participant stated

“[YPiT] provides a safe place for [my child] to create friendships”, another stated, “it helps with meeting in a group of pairs who are similar in age, who are experiencing what you are experiencing and having the opportunity to freely talk”, furthermore, “this gave [my child] the opportunity to learn, and lets [my child] know that it’s okay to be different and to speak your opinion, and that your voice matters”. These results underscore the essential characteristics of effective mentorship mentioned previously, including mutual respect, personal connection, and shared values trust, and empathy (Rhodes, 2004; Straus et al., 2013).

1.58.3.3 Differences Between Mentors and Other Influences

When asked to describe the differences between mentors and other influential figures, participants described mentorship as an informal peer-relationship, with one participant stating, “the rapport that they build is really more of a friendly rapport; they feel they can tell this person things that they might not be comfortable telling other people”. Others discussed the difference in expectations, which allows mentors to be a “safe place” for their child, stating, “the expectations are different, and they can be more non-judgmental”, again highlighting the characteristics defined by previous researchers (Rhodes, 2004; Straus et al.,2013), as well as the reports of safe, trusting environments from Martin & Fisher-Ari (2021).

1.58.3.4 Importance of Representation and Shared Identities with Mentors

Overall, guardians expressed a large importance in having a mentor with a shared identity as their child, and that this aspect was a driving force in participating in the program. One participant stated, “representation matters”, and that “it’s important that we see the significance in having people that look like [my child], especially in the STEM field. Having someone that [my child] can identify with, because there are some things, even culturally, that we say or do, that [these mentors] could pick up on, that others [who cannot identify] cannot, and that is important…with that, I think [participants] will be more open, or feel less judged”.

Many others highlighted how YPiT serves an inspiration to their child to explore different field, including STEM. One parent shared that YPIT “allowed [my child] to see people who look like her in higher education in the STEM field, being as successful as they are”, another shared that “it is good for my child to see someone of his identify in the field… showing that you do not need to be a certain color or background; anyone can make it as long as you put your mind to it… if you be yourself, and you do it with your best ability that you can do anything you put your mind to”. Another discussed YPiT being an opportunity to realize how possible it was for their child to pursue their aspirations of STEM, stating, “[my child] got a chance to see people who look like him that could have the kind of jobs that [they] are curious about…it does not have to be a farfetched thought or idea of [my child] becoming an architect or engineer”. These responses further support the research findings of Sheffield et al. (2021) and the impact of Social Influence Theory (Kelman, 1958); by providing students with role models who have shared identities with them, their interest and belief in scientific exploration is more likely.

1.58.3.5 Academic and Professional Development

In regard to academic and profession development many parents stated that their child’s “love for science has grown”, with another parent stating, “I have really seen [my child] become more interest in science”. Additionally, many shared that their children have enrolled and participated in other educational experiences and resources, such as STEM clubs at school, ACT prep, scientific research internships, and summer programs. Furthermore, YPiT has exposure their children to a variety of fields, with one parent stating, “it helped [my child] understand that there are so many types of STEM fields out there, which allowed [my child] to figure out which one [they] like and to find [their] own little spot in that area”. Others noted how their children’s career aspirations have been constantly changing and that YPiT has helped expand their minds to careers, not just in the STEM field. These results again, complementfindings of previous work that have reported similar increases in academic achievement and interest (Byars-Winston et al., 2015; Centre for Addiction and Mental Health, 2013; DuBois et al., 2002, 2011; Estrada et al., 2018; Rodríguez-Planas, 2012)

Regarding parental support and development, many participants expressed an increase in confidence as a parent by knowing “others are going through similar situations” and that they “are not alone”. One described the program as “a space where I can confide in parents to talk about things and speak freely”. While most guardians commented on parental support and learning within that area, one parent noted how the program has inspired their own educational journey and has since thought about exploring potential programs or certifications to enhance their own educational background.

These responses complementa previous study by Weiler et al. (2020) who found that parents involved in mentorship programs expressed initial hesitations in asking for help, but once involved in the program participants felt support and a connected to a “community” of like-minded people. The involvement of parents within this program is encouraging, according to Spencer et al. (2011), programs where guardians collaborate with mentors and program staff are more likely to see positive changes in youth.

1.58.3.6 Feedback on the Program

When asked about their favorite part of the program, many discussed the opportunities to collaborate, share and work with other parents. Specifically, parents mentioned the importance of the parental support groups that have allowed them to recognize that other parents are going through very similar things and have provided the opportunity to share resources to help one another. As for suggestions for improvement, parents mentioned increasing mentor visibility, meeting more often, scheduling further in advance to make sure they can attend, and finding funding opportunities to enhance the program further. Results from the study conducted by Spencer et al. (2011) also reported parent's desire to meet more often and consistently. However, overall, these responses further highlight the impact of the program, and mentorship as a whole.

1.59 Conclusions

The study's findings underscore a generally positive reception of the YPiT program among educational professionals, with significant percentages of respondents indicating that the program is likely to improve students' science proficiency (66%), interest in science-based careers (55%), and interest in college attendance (64%). Moreover, no significant differences were found in these positive perceptions across different professional roles or school districts, indicating a broad consensus on the program's potential benefits. Furthermore, 98% of respondents indicated that they were likely to recommend the program. Hesitations of recommendation centered around travel and logistics, particularly for schools located far from the program's venue. While our overall results highlight positive perceptions and potential success, they also highlight the need for additional, or more localized outreach. Furthermore, a lack of awareness and familiarity with the program was another common theme. Increasing program visibility through regular updates, presentations, and success stories shared with educators could enhance familiarity and willingness to recommend the program.

Students participating in the program reported increased interest and confidence in STEM subjects, with many highlighting the importance of mentorship and representation. Guardians echoed these sentiments, emphasizing the program's role in providing safe and supportive environments for their children to explore STEM fields. The importance of mentors sharing similar backgrounds with students was particularly noted, contributing to students' comfort and engagement. Both students and guardians observed notable academic improvements and increased interest in STEM careers. The program's hands-on learning experiences and exposure to various STEM fields have helped students gain confidence and clarity regarding their academic and career aspirations. Suggestions for program improvement included increasing the frequency of meetings, enhancing mentor visibility, and securing additional funding to expand the program's offerings. Additionally, better advance scheduling could help ensure higher attendance and participation rates.

In summary, the importance of outreach and mentorship in promoting diversity in STEM and addressing sustainable development in Alabama cannot be overstated. Leveraging social influence theory, the YPiT program demonstrates how positive role models and mentors who share similar backgrounds with students can significantly impact their interest and confidence in STEM fields. By providing a supportive environment and relatable figures, the program fosters a sense of belonging and motivation among students, encouraging them to pursue STEM careers. This is crucial for sustainable development, as a diverse and well-educated STEM workforce is essential for driving innovation and addressing complex challenges. To further this impact, it is vital to enhance outreach efforts, increase program visibility, and address logistical barriers to ensure broader access and participation. Such initiatives will not only promote diversity in STEM but also contribute to the long-term sustainability of Alabama by cultivating a skilled and diverse talent pool equipped to tackle future challenges.

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General Conclusions, and Future Work

The purpose of this study was to understand and address educational inequities within Alabama's education system while developing impactful, relevant, and inclusive learning materials related to sustainability. The study employed four approaches to achieve this goal. The first approach involved assessing the relationship between demographics, educational achievement, funding, and geographic location across Alabama's public-school districts to identify gaps in science proficiency. The second approach focused on the development, implementation, and assessment of a classroom lesson on sustainable forest product materials, integrating active problem-based learning. The third approach consisted of organizing a community event to increase public understanding and practice of sustainability. Lastly, the fourth approach entailed a qualitative assessment of a mentorship program aimed at enhancing science proficiency and interest among minority students. These approaches collectively sought to foster equitable education, environmental awareness, and sustainable development in Alabama

Our first study reveals significant disparities in educational achievement, funding, and demographics between Black Belt School Districts (BBSD) and Non-Black Belt School Districts (NBBSD) in Alabama. Despite receiving more total funding, BBSDs still exhibit lower science proficiency, graduation rates, and college readiness, alongside higher rates of chronic absenteeism. These outcomes highlight systemic inequities and the need for targeted interventions. Further research should explore the longitudinal impacts of funding on academic achievement and investigate local tax funding and income disparities to develop more equitable funding strategies. Addressing these disparities is crucial for improving educational outcomes and fostering sustainable development in historically marginalized regions.

The second study found that integrating relevant, hands-on curriculum in environmental science significantly improves student understanding and awareness of sustainability issues. The increase in student scores and positive teacher feedback across diverse geographic and socio-economic contexts underscore the effectiveness of the lesson. However, translating this awareness into career interest requires additional strategies. Future work should focus on developing comprehensive, active-learning materials aligned with state standards and investing in studies and policies to address academic resource disparities. By enhancing science education, Alabama can progress towards sustainability and better prepare students for future challenges.

The third study found that community outreach events can effectively enhance participants' understanding and practice of environmental sustainability. Significant improvements in knowledge and behavior, coupled with high satisfaction rates, demonstrate the impact of these events. However, engaging a more diverse and less environmentally aware audience remains a challenge. Future efforts should focus on broader community engagement, increased outreach, and longitudinal studies to assess long-term behavioral changes. Enhancing advertising and organizing more frequent events can further promote sustainability awareness and practice.

Lastly, in the final study, the YPiT mentorship program positively influences students' science proficiency, interest in STEM careers, and college attendance aspirations. The importance of mentors who share similar backgrounds with students is highlighted, fostering a supportive and engaging environment. To enhance the program's impact, increasing outreach, improving mentor visibility, and addressing logistical barriers are essential. Future initiatives should focus on expanding the program, securing additional funding, and enhancing communication with educators and guardians. By promoting diversity in STEM and leveraging social influence theory, the YPiT program contributes to sustainable development and prepares a skilled, diverse workforce for future challenges.

Future research should focus on conducting longitudinal studies to investigate the long-term impacts of funding on academic achievement and sustainable education initiatives. By tracking changes over an extended period, researchers can gain a comprehensive understanding of how financial resources influence educational outcomes and the effectiveness of sustainability programs. This will help identify which funding strategies are most beneficial and provide data-driven insights for policymakers. Additionally, there is a need to create equitable funding policies that address local tax funding and income disparities. Policies should be developed to ensure that all schools, regardless of their geographic or economic context, receive adequate financial support. This will help level the playing field and provide all students with equal opportunities to succeed. Policymakers should consider the unique challenges faced by different districts and work towards a more balanced distribution of resources.

Furthermore, developing and integrating comprehensive, active-learning materials aligned with state standards is crucial for enhancing the curriculum. These materials should be designed to engage students in hands-on, problem-based learning experiences that are relevant to their lives and future careers. By making the curriculum more interactive and applicable, educators can foster a deeper understanding of sustainability and environmental issues among students. Also, increasing outreach efforts and organizing more frequent events are essential for engaging a broader audience in sustainability and environmental awareness. Community events can provide valuable learning experiences for students and their families, fostering a culture of sustainability within the community. By reaching out to diverse groups and making these events more accessible, educators can ensure that the message of sustainability is widely disseminated.

Moreover, expanding mentorship programs, improving visibility, addressing logistical barriers, and securing additional funding are necessary steps for enhancing these initiatives. Mentorship programs can have a significant impact on students' interest and proficiency in STEM fields, particularly for underrepresented groups. By increasing the reach and effectiveness of these programs, more students can benefit from the guidance and support of mentors. Lastly, conducting longitudinal studies to assess long-term behavioral changes resulting from educational and outreach initiatives is vital. Understanding how these programs influence behavior over time can provide insights into their effectiveness and areas for improvement. This research can help refine educational strategies and ensure that they lead to lasting, positive changes in students' attitudes and actions towards sustainability.

By addressing these areas, future work can build on the current findings to promote equitable education, environmental awareness, and sustainable development in Alabama and beyond. Implementing these recommendations will help create a more inclusive and effective education system that prepares students to meet the challenges of the future.