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EXPLORING THE ROLE OF GENDER, RACE, FIRST-YEAR COLLEGE GPA AND PASSING STEM ADVANCED PLACEMENT EXAMS AND THE LIKELIHOOD OF GRADUATING WITH A STEM DEGREE: A MULTIPLE LOGISTIC REGRESSION ANALYSIS

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ABSTRACT

EXPLORING THE ROLE OF GENDER, RACE, FIRST-YEAR COLLEGE GPA AND PASSING STEM ADVANCED PLACEMENT EXAMS AND THE LIKELIHOOD OF GRADUATING WITH A STEM DEGREE: A MULTIPLE LOGISTIC REGRESSION ANALYSIS

Science, Technology, Engineering, and Mathematics (STEM) careers are projected to grow beyond the normal pace of job growth (Bureau of Labor Statistics, 2021). Many of these careers will require degrees in STEM fields, but, currently, there is a significant underrepresentation of Blacks and females in both STEM degree programs and careers. The purpose of the current quantitative study was to explore the strength of the association between AP Exams, first-year GPA, race, and gender in science achievement. Research Question 1 investigated the relationship between taking AP Exams and the time taken to graduate. For students who took an AP Exam, the mean graduation time was 11.73 semesters (*Mdn* = 11.00) versus 12.64 semesters (*Mdn* = 12.00) for students who did not take an AP Exam. There was a statistically significant (ρ (9788) = -0.205, $p = < 0.001$) negative correlation between having AP Exam College Credit and Time to Graduation. Research Question 2 investigated if taking AP Exams influenced first-year college GPA. For <u>all students</u>, those with AP Exam College Credit had significantly higher first-year GPAs (*Mdn* = 3.48) than the first-year GPAs (*Mdn* = 2.75) of those without AP Exam College Credit (U = 49685737.5, $p = < 0.001$; r = 0.38). For <u>Black students</u>, those with AP Exam College Credit had significantly higher first-year GPAs (*Mdn* = 2.80) than the first-year GPAs (*Mdn* = 2.05) of those without AP Exam College Credit (U = 346781.0, $p = < 0.001$; r = 0.21). For <u>female students</u>, those with AP Exam College Credit had significantly higher first-year GPAs (*Mdn* = 3.56) than the first-year GPAs (*Mdn* = 2.88) of those without AP Exam College Credit (U = 16696525.5, $p = < 0.001$; r = 0.39). Research Question 3 explored if STEM degree attainment was influenced by passing STEM AP Exams, first-year GPA, race, and gender. A multiple logistic regression model showed that passing STEM AP Exams (OR = 3.017, $p = < 0.001$, 95% CI [2.534, 3.591]) and obtaining a higher first-year GPA (OR = 3.994, $p = < 0.001$, 95% CI [3.269, 4.759]) led to a higher chance of graduating with a STEM degree – 75.11% and 79.98% *more* likely, respectively. Being female (OR = 0.353, $p = < 0.001$, 95% CI [0.304, 0.409]) or Black (OR = 0.562, $p = < 0.013$, 95% CI [0.356, 0.886]) led to a lower chance of graduating with a STEM degree – 26.1% and 43.8% *less* likely, respectively. Being aware of these factors that influence STEM degree attainment, educators can provide targeted interventions and supports that could increase diverse representation in STEM fields. Additional implications include providing greater support systems for first-year students from underrepresented groups seeking STEM degrees as well as encouraging these students to take more Advanced Placement STEM courses in high school.

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CHAPTER I: INTRODUCTION

The current study focuses on STEM (science, technology, engineering, and mathematics) degree attainment at a regional, four-year university with an emphasis on the representation of race groups (specifically Black) and gender in STEM degree attainment. Additionally, the study seeks to investigate the role of a potentially controllable variable in high schools (passing Advanced Placement Exams) in relation to increased STEM degree attainment at a regional university. Initially, a search through recent literature appeared to show some trends between race/gender and STEM degree attainment as well as a comparison to national trends in other areas such as STEM job attainment (Burke et al., 2022). The literature indicated a potential relationship between race/gender and STEM achievement. Existing data were collected and analyzed to determine whether this trend occurred for a specific data set. Further analysis of data was conducted to determine if passing STEM Advanced Placement Exams was a determining factor in STEM degree attainment rates.

Statement of Problem

Science and engineering careers in the United States are projected to grow by over ten percent by the year 2031—far greater than careers in other fields (Krutsch & Roderick, 2022). These science and engineering professions also show greater hourly pay rates and salaries compared to other fields. An examination of college science and engineering degrees (more specifically STEM—science, technology, engineering, and math) showed an increase in degrees awarded (associate's, bachelor's, master's and doctoral) across universities in America (Trapani & Hale, 2022). However, it appears that many underrepresented groups (e.g., Black and Hispanic) are underrepresented in these STEM fields (Burke et al., 2022). Generally, it is also worth noting that females earned a higher percentage of bachelor's degrees when compared to males in 2015-2016 (58% to 42%), but in STEM, females earn a lower percentage of bachelor's degrees than males (36% to 64%; National Center for Education Statistics, 2019). These disparities are of interest to the current research study.

Over the years, the United States has grown more aware of the importance of STEM education to the future of the country. Additionally, greater attention has been brought forward about equitable academic opportunities afforded to children across various racial and gender lines. In fact, schools are required by the United States Department of Education to develop and implement strategies in their schools that will help address the issue of disparities in standards achievement (Spearman, 2017). With the future trending towards a greater dependence on STEM careers and higher paying jobs in those careers, students of all backgrounds should be adequately represented in those fields. If the nation hopes to build toward a more equitable workforce, the diversity of our nation should be reflected in the makeup of our STEM workforce.

Positionality Statement

I chose to study issues relating to STEM because they have had an impact on my career as a high school science educator. Preissle (2008) argued personal experiences and relationships can often spark the initial interest in a research study. Further, these experiences can also help build credibility and authenticity for an investigation. Although Preissle (2008) focused on qualitative investigations, cross-over for quantitative and mixed-methods approaches can also be inspired by personal experiences. My own ontological experiences are pragmatic and transformative, which ground my epistemic methods. Moon and Blackman (2014) describe these experiences. A pragmatic ontological experience involves encountering reality in a way that is grounded in practicality and usefulness, while also exploring questions about the nature of existence and being. This means that I look at abstract ideas with a practical mindset, seeking solutions that have tangible applications in daily life. A transformative ontological experience is a deeply personal encounter with daily life and can lead to profound shifts in consciousness, perception, understanding, and interaction with others. Recent updates to the American Psychological Association (2020) Style Guide have shown that it is appropriate to use the first-person view when writing professional publications. The “no first-person” ideology is giving way to the notion that first person can be interspersed throughout a study, regardless of the methodology or design. The 7th edition update of the APA Style Guide also encourages using these first-person pronouns to avoid ambiguity (American Psychological Association, 2020). Greenbaum (2021) further described using first-person pronouns when describing any personal experiences, thoughts, or actions (related to the study) taken by the researcher. I align closely with this updated perspective, so I will use first-person pronouns in specific parts of this dissertation. The purpose of alternating between active and passive voice is to emphasize personal experiences and viewpoints.

Personal Motivation

I am currently an educator at a National Center for Education Statistics (NCES)-classified rural-fringe high school in Kentucky. The school belongs to one of the largest and most diverse county districts in the state. Our district along with the city school district fields seven high schools. The school is comprised mostly of Caucasian students and staff, and we are often one of the highest achieving schools in the state in almost every academic measure (Kentucky Department of Education, 2022). I teach in a STEM field and have taught courses at various levels (conceptual/remedial, general, advanced, and Advanced Placement). Over the decade of my teaching career, I have found that, although our school has a low Black to Caucasian population ratio, the ratio is significantly lower in my advanced and Advanced Placement courses. Why is this the case? Is there an underlying factor that keeps students from taking upper-level courses in STEM areas at our school? While the foundational cause is extremely important to discover, at the moment, I want to focus on the long-term implication of this disparity. I am hoping to find a way to increase the chances of underrepresented students beginning and successfully attaining STEM degrees, so they can have access to higher paying careers in the future. As a high school teacher, I may not be able to change what has happened in the educational past of the underrepresented students in my school, but I can work with my colleagues and administration to encourage and support underrepresented students to take more challenging coursework.

Purpose

The purpose of the current study is to explore any association that AP Exams, first-year GPA, race, and gender might have in science achievement. For the purpose of the current investigation, science achievement is defined as passing Advanced Placement Exams as well as earning undergraduate BA/BS STEM degrees. The current study will examine data from a four-year, comprehensive, regional university located in Kentucky (NCES classified as City: Small). Three research questions will investigate various independent aspects of science achievement. One question will focus on race-related data; one will focus on gender-related data; and one will look at the interaction of passing Advanced Placement Exams and degree attainment. There are limited existing data from the College Board regarding any correlation between the relationship between Advanced Placement results and STEM degree attainment when looking at data of specific student populations.

Methodology Overview

The current study utilizes a quantitative methodology approach using existing data found in open databases or specifically requested from institutions. Since the degree attainment area is focused on a single university, data were requested from a regional university's office of institutional research. All data are listed as either aggregate data or individual student data without any student identifiers (e.g., school ID number, name, social security number, birth date). Institutional research provided the data as requested. No further segregation of the data was needed other than removing data points that did not meet the minimum criteria for this study (e.g., students who enrolled but did not graduate). The cohort data obtained was for students starting in Fall 2012 through students starting in Fall 2017. Only data for first-time, full-year, full-time students who successfully graduated by Spring 2023 were considered for the current study. Transfer students were not considered in this exploration. The data were obtained from the university in Summer 2022 and updated in Fall 2023.

The data were entered into a statistical analysis software (IBM SPSS Statistics, Version 29.0.1.0(171)) for analysis. When analyzing and discussing the findings of the study, it is important to note that each research question (presented below) deals with an independent aspect of our purpose (science achievement). The results of one research question are not intended to impact or suggest any information about any other research question.

Significance of Study

The role of race/gender in STEM education and careers is very complex. Literature shows that, in general, females and Black student groups are underrepresented as compared to the total population (Guevara-Ramirez et al., 2022; Hanson, 2012). It appears that underrepresentation in STEM careers ultimately comes down to underrepresentation in STEM degree attainment. But what is the cause of this? A variety of complex factors, including a lack of push from grade school and traditional gender/race roles in society, help explain why females and certain racial groups do not feel like they can pursue science careers (Barres, 2006; Jacobs & Simpkins, 2005). Societal pressures or expectations and historical oppression may also play a role. While foundationally important, these complex variables are not the focus of the present study.

As a high school educator, I believe it is important to know what can be done at the high school level to help students feel more confident in their STEM abilities. Doing so would encourage a larger number of female and Black students to pursue future educational and career goals in STEM fields. If the current study shows that taking Advanced Placement courses and passing the exams leads to a higher chance of these populations earning STEM degrees, then schools can use this information to encourage all students, especially female and Black students, to take Advanced Placement courses. Further, taking and passing Advanced Placement Exams may lead to these students being more successful in their collegiate STEM endeavors. Anecdotal evidence suggests schools tend to recommend that students take courses they can easily pass to earn required credit. Further, if the results of this study showcase a strong relationship between passing STEM Advanced Placement Exams and STEM degree attainment, wide-scale studies utilizing larger universities and nation-wide data may provide evidence that could lead to changes in educational policies to encourage students (especially the groups of interest) to take advanced science courses. Financial support along with other measures (such as tutoring and exam preparation) may be provided by the local, state, and federal governments for programs that help students pass Advanced Placement Exams. The ultimate goal is greater representation in STEM degrees earned by females and Black students, as well as greater representation in STEM careers.

Research Questions

The purpose of the present study is to explore the role of AP Exams, race, and gender in science achievement. To examine the role of race and gender in science achievement, it is important to consider each factor separately. The first research question explores any impact that Advanced Placement Exams have on the semesters needed to graduate. The second research question explores the relationship of race, gender, and Advanced Placement Exams. The final research question explores how various factors relate to the ultimate goal of STEM degree attainment at a regional university.

- Research Question 1
    - Is there an association between having Advanced Placement (AP) Exam College Credit and Time to Graduation?
        - *Null hypothesis: There is no association between having AP Exam College Credit and Time to Graduation.*
        - *Alternative hypothesis: There is a positive association between having AP Exam College Credit and Time to Graduation.*
- Research Question 2
    - 2a: Is there a statistically significant difference in the first-year college GPA of <u>all students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?
        - *Null hypothesis: There is no statistically significant difference in the first-year college GPA of <u>all students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit.*

    - *Alternative hypothesis: There is a statistically significant difference in the first-year college GPA of <u>all students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit.*

- 2b: Is there a statistically significant difference in the first-year college GPA of <u>Black students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?
    - *Null hypothesis: There is no statistically significant difference in the first-year college GPA of Black students between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit.*
    - *Alternative hypothesis: There is a statistically significant difference in the first-year college GPA of Black students between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit.*
- 2c: Is there a statistically significant difference in the first-year college GPA of <u>female students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?
    - *Null hypothesis: There is no statistically significant difference in the first-year college GPA of female students between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit.*
    - *Alternative hypothesis: There is a statistically significant difference in the*

first-year college GPA of female students between those who have earned Advanced Placement Exam College Credit and those who have no AP Exam College Credit.

- Research Question 3
  - Which of the predictor variables (passing STEM Advanced Placement Exams, first-year GPA, gender, and race) are associated with the likelihood of graduating with a STEM degree?
    - *Null hypothesis: The predictor variables (passing STEM Advanced Placement Exams, first-year GPA, gender, and race) are not associated with the likelihood of graduating with a STEM degree.*
    - *Alternative hypothesis: The predictor variables (passing STEM Advanced Placement Exams, first-year GPA, gender, and race) are associated with the likelihood of graduating with a STEM degree.*

Quantitative analysis of these three research questions could lead to findings about the current role of AP Exams, race, and gender in science achievement and may allow for the formulation of recommendations for future studies and interventions.

Limitations and Delimitations

Each study has limitations and delimitations that will impact the overall applicability of the findings to other studies and into practice. The limitations are possible areas out of my control as an investigator. The population used in the current study is a regional university that typically fields students from the local area of the small city and rural Kentucky. Thus, the diversity in the population may not be indicative of the diversity represented nationwide or in a school-wide setting. The investigator has chosen specific parameters defining science achievement: passing STEM Advanced Placement Exams and earning STEM degrees. The data provided only show information on students who have earned STEM degrees. It does not indicate information about students who started with a STEM major but then changed majors. There is also an assumption that all students had equal access to STEM Advanced Placement programs at their high schools. While this may not be true in all cases as Advanced Placement programs are waning, it is difficult to analyze which students had this opportunity.

Delimitations are specific parameters established by a researcher to focus the scope of the investigation. A delimitation of the current study was that only specific disciplines were classified as STEM degrees. Because first-year students were considered, the data utilized does not include transfer students. Gender is based on what students identified on their admission application to the regional university. Finally, the COVID-19 pandemic impacted educational institutions, Advanced Placement Exams, as well as the general student educational process. While the COVID-19 impact is mentioned in the literature review as an important background consideration, the results will be presented as if there were no COVID interruptions. It is difficult to quantify the impact that the pandemic had on specific groups. Finally, the considered exams are AP Biology; AP Calculus AB; AP Calculus BC; AP Chemistry; AP Physics 1; AP Physics 2; AP Physics C: Mechanics; AP Physics C: Electricity and Magnetism; and AP Statistics. Due to the irregular use across high schools, the two AP Computer Science exams were not included in the group of AP Exams of interest to the present study. In many schools, the course is often housed in the technology/business department rather than the science department. Additionally, the AP Computer Science exams were restructured in significant ways over the last decades. Handling data from the reconstructed exam versus the old exam would require more complex considerations.

Conceptual Framework

The modern American education system seeks to provide instruction to all children in America. Further, legal and societal changes over the last several decades have shaped the modern education system, which seeks to promote equitable instruction regardless of the student's background. In this investigation, the overarching goal is to see how achievement in science education may differ for underrepresented groups of interest. The study is rooted in three major pillars: equity/inclusion practices, educational poverty, and critical race theory.

In the modern education era, there is an emphasis on addressing the achievement imbalance seen between racial groups in specific areas of study. Many universities and school districts have created policies that address diversity, equity, and inclusion in the classrooms (Rogers & Pagano, 2022). Many of the established policies ask educators to reflect on their practices and make changes that would allow students to feel more welcome, respected, and comfortable in the classroom but also design lessons that make the content more accessible for all students. Many tools are also used by organizations to analyze the current state of diversity, equity, and inclusion across their university/district (Cumming et al., 2023). The current study will look at the possible imbalances between underrepresented groups and science achievement.

Educational poverty focuses on understanding how limited access to quality education negatively impacts a student's ability to gain essential knowledge and skills that would set them up for success later in their academic and work life (Allmendinger & Leibfried, 2003). This idea transcends race lines, as it focuses on access. However, we see that racial minorities tend to be heavily represented in this group. Families who struggle to make ends meet or families who come from economically disadvantaged areas often find it difficult to place emphasis on purchasing educational resources, engaging in several academic experiences (due to financial restrictions), having positive role models, and attending well-funded schools with well-trained educators. Further, many impoverished communities have residents who focus on attainment of basic needs and self-fulfillment. Maslow's Hierarchy of Needs demonstrates the importance of having these needs in place before individuals can focus on enriching their academic goals. Ultimately, we see that educational poverty holds individuals in this cycle and makes students, in the end, less prepared with the skills needed to succeed in college or the workforce, thus limiting socioeconomic mobility and the ability to break the cycle of poverty (Glaesser, 2022).

Racial disparities exist in science achievement (Spearman, 2017). Understanding the root of this disparity requires us to look at the role of race in a larger context. Critical Race Theory (CRT) provides one possible viewpoint on understanding the complexity of roles in society as a function of racial background. CRT is rooted in helping society understand this relationship to modify our laws, justice system, and general outlook to provide life circumstances that are fair and just to all people (Crenshaw, 2011). While CRT was originally discussed and analyzed in collegiate environments to describe the intersection of race and systems of power and privilege within the justice system, it has expanded to describe the inequities in many aspects of society - including education (Arnett, 2022). Some important tenets of CRT as it relates to education include analyzing educational policies that may unintentionally impact racial groups in disproportionate ways; understanding that many standardized tests for success, mastery, and/or achievement may have potential biases that benefit one group over another; and learning that historically, curriculum has underrepresented racial groups and cultures. One of the goals of CRT is to work towards interest convergence. This convergence describes how progress can be made equitably when the interests of dominant and minority groups align (Milner, 2008). Recognizing and understanding the underlying structures, both historical and present, can help all people, regardless of race, more clearly see a more equitable future. Once this vision coexists between these groups, specific steps can be designed to help reach these desired outcomes. As unintentional racially oppressive structures within education (and society as a whole) are dismantled, opportunities afforded to underrepresented groups may raise their chances of academic success. The present study does not delve deeply into the understanding of Critical Race Theory, nor does it aim to bolster any claims of the theory. CRT has become a divisive and politically charged issue in recent years, with many school districts banning its teaching (Hodge et al., 2023). Instead, the theory serves as a foundation for this research study, providing a framework to underscore its significance.

Definitions and Terminology

Advanced Placement:

This is often simplified to the acronym AP. This is a program offered by the College Board. These courses are taught at the college level but in a high school setting. Students take a course and decide whether to take the national Advanced Placement Exam.

Advanced Placement Exam:

This is often simplified to AP Exam. This national exam is provided by the College Board and administered by schools. Passing an AP Exam gives students the opportunity to earn college credit for courses that are typically more rigorous than what Dual-Credit courses provide. Note: In Spring 2020, students were allowed to take AP Exam at home due to the COVID-19 pandemic.

Advanced Placement Exam Success:

Success on an AP Exam is often called “passing” the exam. AP Exams are given a score up to 5. Earning a score of 3, 4, or 5 is considered passing. Table 1 shows the interpretation for each AP Exam Score (College Board).

College Board:

This educational organization facilitates and governs the Advanced Placement, SAT, PSAT, and CLEP programs and examinations.

Degree Attainment:

Degree attainment is defined as earning an undergraduate Bachelor of Art or Bachelor of Science degree from the university of interest. Students who transfer in or out of the university or those who do not graduate will not be considered in the present study. Additionally, graduate degrees (master's or doctoral) will not be considered in this study.

Graduation:

Graduation is defined as earning a bachelor's degree regardless of the time taken within the study period.

Graduation Time:

This is the number of semesters between initial enrollment in college up to graduation. Each calendar year consists of three semesters: Fall, Spring, and Summer. For example, a student who starts Fall 2012 and graduates Spring 2016 will have a graduation time of eleven semesters.

GPA:

This value represents the grade point average of a student based on their score in the credit-bearing courses they have completed. College graduating GPA is the grade point average of the student at graduation, while the first-year GPA is the grade point average at the end of the first year of college.

Underrepresented Groups:

Underrepresented groups will be utilized to represent the groups of interest in the current study.

- When looking at gender, minority groups represent students who have indicated their gender to be female on their university profile. Students who decline to identify their gender will not be included.
- When looking at race, underrepresented groups represent students who indicated their race as Black or Black on their university profile. Students who indicated they were two or more races will not be counted in the Black subject group. Students who decline to identify their race will not be included.
- While there are critical differences that exist between the application of race descriptors, such as White versus Caucasian or Black versus Black, these terms will be used interchangeably. This is done because various pieces of literature, reporting from the university of interest, and the College Board do not have a consistent terminology between the sources.

STEM:

This acronym means Science, Technology, Engineering, and Mathematics.

STEM Achievement:

For the high school level, achievement means passing a STEM AP Exam. For the college level, achievement is defined as earning a STEM degree.

STEM AP Exams:

The following exams will be considered STEM Exams: AP Biology; AP Calculus AB; AP Calculus BC; AP Chemistry; AP Physics 1; AP Physics 2; AP Physics C: Mechanics;

AP Physics C: Electricity and Magnetism; and AP Statistics. The current study will not examine whether a student took multiple STEM AP Exams. As long as they have passed one of these exams, they will be considered a participant who has passed a STEM exam.

STEM Degrees:

The regional university that provided the data for the present study offers a variety of degrees in the STEM fields. This study considers the following areas as STEM majors: Biology, Chemistry, Engineering, Geology, Mathematics, and Physics.

Table 1

Advanced Placement Exam Score Scale Table

AP Exam Score	Recommendation	College Course Grade Equivalent
5	Extremely well qualified	A+ or A
4	Very well qualified	A-, B+, or B
3	Qualified	B-, C+, or C
2	Possibly qualified	—
1	No recommendation	—

Note. Obtained from the College Board Website.

Summary

This chapter provided an overview of the investigation. The statement of problem, purpose, methodology overview, significance of study, research questions, limitations/delimitations, conceptual framework, and definitions/terminology have been outlined to help build the case for this research. Overall, the primary objective is to examine factors relating to underrepresented groups and their outlook in STEM academic and career endeavors. The current study aims to explore the potential role of race and gender in science achievement, which will be investigated by looking into three research questions using a quantitative methodology of existing data.

Chapter 2 will delve into the related literature, which will continue to support and build the case for the present study. Important facets of science education, racial and gender disparities in education, as well as science as a career will be examined. Chapter 3 will explain in detail the methodology used to analyze the existing data. Chapter 4 will provide the results of the analysis of this data. Chapter 5 will interpret the findings, draw conclusions, and make recommendations for action and future studies.

CHAPTER II: LITERATURE REVIEW

Introduction

Chapter 2 will discuss important background information as it relates to the purpose of the study and the research questions. The literature review will discuss: (1) Science in America, (2) Homework, (3) Advanced Placement Exams, (4) STEM Career Outlook, (5) Women in Science, (6) Blacks in Science, and (7) Inquiry Classrooms.

The chapter provides some of the background literature examining the relationship between underrepresented groups (specifically women and Blacks) and science achievement. The long-term goal is to suggest methods of increasing the representation of these groups in STEM careers.

Science in America

The public's perception of science is incredibly important when it comes to the longevity and growth (achievement) of science programs in the United States. Public perception of science can impact government and public funding, as well as students' openness to study science and enter STEM careers (Besley & Hill, 2020). As public perception intertwines with political decisions, it is important to note what education looks like for our communities rather than solely relying on perception.

The idea of public education in the United States brings to mind the highest level of learning for all students. Unfortunately, this does not always seem to be the case (Carey & Harris, 2016). Public school does not mean equal school. Often, schools vary from community to community or zip code to zip code and often can be a function of household income (Morgan, 2020). Differences in teacher quality (gauged by certification), funding, facilities/technology adequacy, and several other factors set some American students on the path to success while others are just “getting through” school (Alliance for Excellent Education, 2013; Baker et al., 2017; Carey & Harris, 2016). Additionally, low teacher salaries and increased demands on educators are leading to experts in content areas taking jobs outside of education or in “better” districts (Balingit, 2015; Long, 2019). Many of these factors have a direct impact on student learning–especially those who are from areas of lower socioeconomic status or high minority populations. We see that these inequities in general education can have an impact on science achievement as well (Jackson & Ash, 2012).

Perna et al. (2009) showed that the percentage of United States bachelor’s degrees in science fields are much lower than those of several other industrialized nations. This same trend exists for higher levels of education (master’s and doctoral). There has been a perception that many other nations are pumping out degrees, but their students may not be as strong critical thinkers as the products of American colleges. We have seen that this is not the case. China has renewed its focus on a knowledge-based economy which is resulting in higher spending on STEM education (Zhou & Leydesdorff, 2006). Significant increases in societal acceptance of science careers as well as STEM degrees has been a result of this push. Additionally, the expansion of research and development has been exponentially growing. China has become the largest publisher of scientific articles (Tollefson, 2018). Tollefson argued that while the United States remains a scientific powerhouse, international competition is growing.

Scientific innovation is often a factor of government investment in the sciences. A Pew Research Center report from 2020 showed that most Americans find it important that the United States be the world leader in scientific achievement (Funk et al., 2020). However, the last few years have shown that partisan politics are starting to have an impact on the perception of science in our community. Funk et al. found that 67% of Democrats (and those leaning left) say they have a lot of trust in scientists to do what is right for the country, while only 17% of Republicans (and those leaning right) feel the same way. With the inequities that already exist in education, will politics continue to drive the mindset and, ultimately, the pursuit and funding towards scientific achievement in the future? The current partisan view on the role of science in society has not been the only occurrence when politics has driven public perception in education. The debate on homework, arguably a cornerstone of the American education system, has seen a similar trend and can provide a bellwether for the general state of education at various points within the history of our nation.

Homework: A Case Study

When looking to the future of science education and its effectiveness with respect to various underrepresented groups, it is important to consider the history of education in America and the way stakeholders perceive it. Many students noted that their most negative perception of grade school comes from memories of homework (Moorhouse, 2021). This part of the literature review will explore education and homework policies through the last few decades. A detailed case study of homework serves as a background for the state of education at various points in American history, which also serves as a backdrop for the conceptual framework of the current study: inclusion, educational poverty, and Critical Race Theory.

Many educators and other stakeholders (e.g., administrators, parents, students) may see the disadvantages of homework but understand that it is a part of formal education. These stakeholders often differ on how homework should be designed, assigned, and graded. Cooper and Valentine (2001) described that the controversy over homework is not unique to a particular school setting, demographic, or performance level. They assert homework policy changes (either more strict or more lenient) may encourage students of underrepresented STEM groups to gain confidence in the scientific disciplines. Since many stakeholders see teachers as the ultimate authority on assigning homework (and many school policies give teachers autonomy when it comes to homework), the purpose of this literature section is to explore the evolution of the use of homework in education over time.

Historical Perspective

A historical look at the use of homework provides some insight into the current state of education. During the 19th century, rigorous education and homework was often only assigned to high school students (Reese, 1995). Because the number of students attending non-mandatory high school was smaller than today's standards, many students and parents of high school students were motivated and did not view homework as a major problem. They understood and accepted that homework was part of the "contract" that came with schooling. This perpetuated a long road of educational disparity. Many underrepresented groups were unable to attend high school during this period. Gill and Schlossman (1996) stated that homework was assigned to younger grades so students could master topics based on rote learning and memorization. Thus, homework served the role of rehearsal learning. Students who never entered formal education beyond the early years relied on rehearsal learning rather than working towards greater critical thinking.

In the first half of the 1900s, the passive view on education began to change as the progressive education movement started to grow. The catalyst of this change was the emerging medical field of pediatrics that began to support the notion that homework had become a health hazard for children (Gill & Schlossman, 2004). This led to further investigation into the relationship between drill-based education processes and later homework. Rice (1897) found that arduous spelling homework did not have any impact on higher academic achievement. During this period, homework and rote-learning became the center of many educational controversies probably because many more students were mandated to attend school, and homework became something that students and parents did not agree to do or anticipate. Many began to see homework as a threat to children's health (Gill & Schlossman, 2004). In fact, the American Child Health Association coupled homework with child labor in 1930, and many researchers even considered homework to be "legalized criminality" (Nash, 1930). This argument seems to persist today, as greater focus is placed on social-emotional learning and the long-term impact on mental health. We see underrepresented communities often put homework in the back of their mind and do not find as much value in it (Dunatchik & Park, 2022).

By the middle of the 20th century, the progressive movement was beginning to diminish, and an academic excellence movement was beginning to emerge in part as a reaction to the Cold War. Many began to blame the de-emphasis on rigorous, science-driven education in the past as a cause for the United States lagging behind in the Space Race and technological sciences. More emphasis was bestowed upon homework and learning rigorous content (especially STEM areas) so American children would be as hardworking and as smart as Russian children (Gill & Schlossman, 2004). Thus, schooling and learning became part of being an American and a patriot. Again, it appears that societal and cultural conditions in reference to race relations in America proved to put some groups on a path for educational success, while other groups were given the bare minimum. More research and a better societal attitude improved homework's status in society. Parents and students may not have wanted homework, but they accepted the importance of it. Parents often set specific times for students to sit at the kitchen table and complete work. The amount of homework tripled for most students; parents supported this increase. In fact, 51% of parents in 1959 believed that more homework should be given to students (Gill & Schlossman, 2004). This passion for homework again changed in the 1970s as students began having a general lack of interest and respect for education (arguably for authority, in general). The schooling movement took a step back as other social movements took center stage. This eventually led to the birth of another academic excellence movement in 1983 that attempted to bolster education by involving politicians, parents, students, educators, and other stakeholders to fight against the "rising tide of mediocrity" in education (National Commission on Excellence in Education, 1983). Education was becoming increasingly political.

The growth in academic standards shifted again around 1999-2003. Parents and students were complaining about too much homework and pushed for a reduction in the amount of work outside of school hours. More research into mental health and trauma started to support the need for time away from the stress of school. Winerip (1999) reported that students were given so much homework that they were unable to enjoy learning; they had become "homework bound," as the title of the article suggested. There was a general dissatisfaction with the educational process amongst students and parents. By the mid 2000s, the role of homework rose to prominence again in educational research. More emphasis was being placed on teacher perception of homework and the types of homework assigned. Homework was now critically being analyzed side by side with the effectiveness of the current educational process and practices. Additionally, educational reform occurred to identify and to support struggling students, especially those in inner cities and from lower socioeconomic status groups (Reardon, 2013). Racially underrepresented students often comprise the majority of these inner-city groups where educational poverty is high.

Does Homework Actually Work?

Keeping in mind that an investigation on homework can expose the educational practices that lead to science achievement across all demographics, it is important to determine if it is effective. Cooper (1989) defined homework as tasks that are given to students by the teacher which are intended to be carried out before or after school hours. This will be the working definition used in the current study. Can the typical student achieve the same level of mastery with or without doing homework? Early research done by Cooper (1989) found that academic success in homework-based courses was higher than courses where homework was not assigned. Later research by Cooper et al. (2006) found that studies showing patterns in homework had design flaws and argued that the association between homework and achievement may need further research studies. Fan et al. (2017) indicated that the homework-science achievement relationship was strongest for U.S. students in the areas of math and science. The authors also showed that homework and science/math achievement relationship was stronger for elementary students and high school students than middle school students. Sailee and Rigler (2008) found that 62% of investigated students spent at least four hours a week doing extra-curricular sports/clubs. With this amount time devoted to extra-curriculars in addition to familial and work obligations, many students and parents argued there was not sufficient time left to complete long assignments. Thus, critics said that homework was not as effective because students were unable to put forth the required time. However, Kalenkoski and Pabilonia (2017) showed another perspective using real data reported to the Child Development Supplement (1997-2008) and the Transition to Adulthood Survey (2002-2008). Their study (using many variables such as high school GPA as well as presence at college by age 20) found that homework time has a positive impact on males in terms of achievement. Do we see the same trend for female students? With STEM courses requiring both rehearsal/rote-learning as well as regular practice, homework is an essential part of the science classroom. Is this well perceived by the stakeholders?

Perception of Homework

The perception of homework and student motivation seem to be important factors that should be considered. Hoeke (2017) found that parents typically have more positive perceptions of education and homework than teachers. Further, it was found that high school educators found greater purpose in homework than elementary and middle grades teachers. Teachers perceived that homework should be assigned for practicing skills (Adams, 2014), learning/reviewing important content (Brock et al., 2007), and practicing soft skills such as time management and critical thinking (Peltier, 2011; Ramdass & Zimmermann, 2011). Students, however, often understand the value of homework but are more critical of it. Wilson and Rhodes (2010) found that 39% of respondents completed their homework frequently and 69% of respondents thought homework was meaningful, while 73% found homework boring. Of course, many factors can play a role in student perception of homework, such as socioeconomic status, performance history, and prior educational experiences (Xu, 2010). We see variations between different stakeholders in the view of homework. Even within the groups, there are differences in the role and application of homework in a classroom. With varied homework policies in classrooms across a school, how does this relate to the way content is presented to students and building engagement in the discipline?

Homework in Today's Society

As technology continues to revolutionize society, the education field has started integrating technology more heavily. One of the major complaints that teachers have regarding homework is the amount of grading (Tas et al., 2014). Students often complain about the amount of writing and the delayed teacher feedback on homework. One of the key changes that has reshaped homework is the use of learning management systems (e.g., Blackboard, Canvas, Schoology, and Google Classroom) and other online homework platforms (e.g., Mastering and MathLab). Online homework removes some of the disadvantages of traditional paper and pencil homework by providing timely feedback, instant grades, summaries of individual- and class-level performance, and question-type varieties. In a randomized study of 2,850 math students, end-of-year standardized math tests scores significantly improved in the group that received the online homework treatment (Roschelle et al., 2016). Online homework seemed to have a positive impact on all students but had the greatest impact on students with low prior math understanding. Similar results indicated that using an online homework system improved performance on an engineering final exam: 79% average for students with online homework versus 70% average for students without online homework (Arora et al., 2013).

Of the many benefits of online homework, one of the greatest resources for students is the option to have multiple attempts. Online homework systems can be set to allow students to have multiple attempts at a problem; some systems even provide hints to students if they are struggling. Kortemeyer (2015) found that the optimal number of attempts for a homework problem was five opportunities to get the answer correct. More advanced online homework systems currently being utilized are adaptive. These homework systems continue to build a customized assignment as students are working through the assignment by analyzing what the student is getting correct and incorrect. Adaptive systems have been found to increase overall final grades in a course compared to typical response-based online homework (Richards-Babb et al., 2018). Online homework may have a strong relationship with achievement. With many schools becoming one-to-one with student laptops reducing technological disparity, this might be another way to encourage students from populations underrepresented in STEM fields to build their confidence in STEM and pursue higher education programs. The advent of online education seems to have transformed learning into a new era, but it has impacted learning disproportionately (Brown, 2000). Families of lower income are less likely to have the financial means to purchase academic software and devices (Rafalow, 2021). Schools in areas that are underfunded (often serving high diversity or inner-city areas) are not able to have access to advanced, technological platforms. As technology begins to enhance the learning process, the disparity in our learners may be growing. Pew Research Center (2023) described the gap in learning and how it disproportionately impacted underrepresented students during the COVID-19 pandemic as schools shifted to remote instruction. The inability to complete lessons and assignments at home due to technology constraints created a digital "homework gap."

What Does Homework Tell Us?

This case study into homework helps describe one aspect of how the educational system has changed over time. Access to quality education throughout the history of our nation has not been equal nor equitable, with underrepresented groups (such as Blacks and women) on the side of lesser access (Hatcher, et al., 2022). As the nation's and stakeholders' views on homework have changed over time, social policies such as racial rights and gender rights were much slower to keep up. Segregated schools received lower funding which negatively impacted the quality of the education delivered (Armwood, 2018). Even today, schools serving high underrepresented areas are often underfunded and lack quality educational resources. Homework becomes a critical agent in fostering learning outside of the school day and building soft skills that allow a student to be successful in future educational endeavors (Peltier, 2011; Ramdass & Zimmermann, 2011). Thus, the state of homework can be treated as a bellwether for the state of education in general.

Homework has also been shown as an indicator for success in areas of academic achievement. Advanced Placement courses typically require students to complete more weekly assignments (homework) and emphasize that homework becomes a practice and study tool. Ober et al. (2024) indicated a positive correlation between completing homework and end-of-year grades and Advanced Placement Exam scores. Griffin and Townsley (2022) provided evidence that while homework is, in itself, a positive influence on minority student success, equitable grading practices must also be present. With grading practices that take into account the educational background of the student, homework becomes a more powerful tool for success.

Advanced Placement Exams

From 1992-2012, there was a massive growth in the Advanced Placement Program across the United States (and internationally) (Judson, 2017). There was an increase in the number of schools offering AP courses by 83% and an increase of 485% in the number of students completing at least one AP exam. The College Board offers AP Exams in several areas spanning various disciplines. As of Fall 2023, the College Board website shows there are 39 courses offered spanning seven subject areas, including AP Capstone (2), Arts (5), English (2), History/Social Science (9), Math/Computer Science (6), Sciences (7), and World Languages/Culture (8). These courses offer students the opportunity to take college-level courses and earn credit for these courses by earning a passing score on the related AP Exam. Table 1 (found at the end of Chapter 1) shows the range of scores and interpretation for each score. The biggest draw of these courses is the chance for schools to achieve higher rankings on accountability measures (Morse, 2016) and the potential for earning college credit that will allow students to bypass these courses in college, saving time and money (Klopfenstein & Thomas, 2010). While there is value in simply taking AP courses, Warne et al. (2015) suggested that taking and passing AP Exams has been shown to produce higher ACT scores as well. These variables may not solely indicate a cause-and-effect situation. Other important factors can include students' dedication and general reasoning ability required to pass an AP Exam, which is often inherent to many students who might have scored well on the ACT regardless of taking an AP Exam. Analysis of data conducted by the College Board shows that there are benefits to students who earn non-passing scores of 1 or 2 on AP Exams. They showed, "AP students, including those with average scores of 1 or 2, are more likely to enroll in a four-year college compared to academically similar students who did not take AP in high school" (College Board, 2021). Figure 1 shows this data trend for research conducted by the College Board. It appears that there is value in taking AP courses even if the student does not pass the related end-of-course AP Exam.

While Figure 1 indicates that regardless of the score earned by students, taking AP Exams appears to lead to higher enrollment probabilities in four-year colleges. Beard et al. (2019) indicated that taking one to two AP Exams seemed to boost first-year GPA as well as on-time graduation for students. Further, taking AP courses and passing AP Exams leads to higher outcomes in college than taking dual credit courses (Chajewski et al., 2011; Wyatt et al., 2015).

Figure 1

Four-Year College Enrollment Probabilities, by Average AP Score (College Board, 2021)

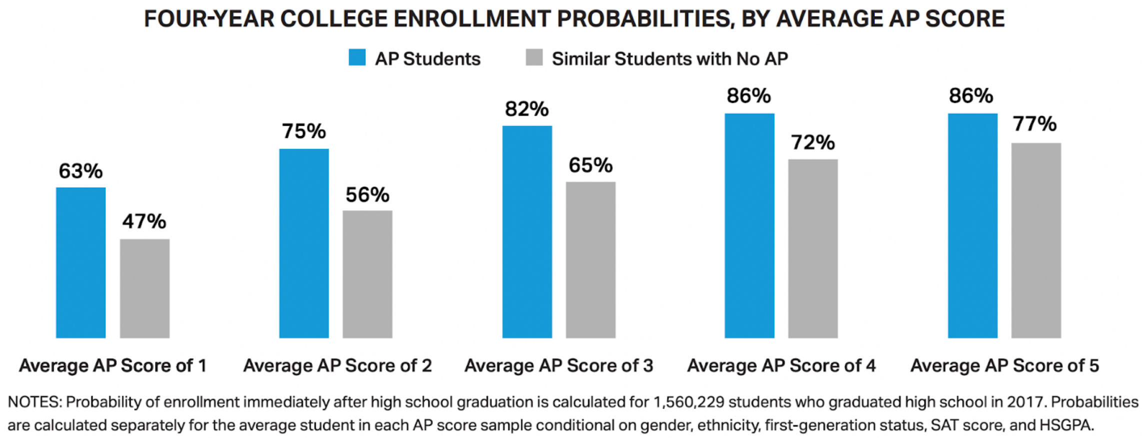
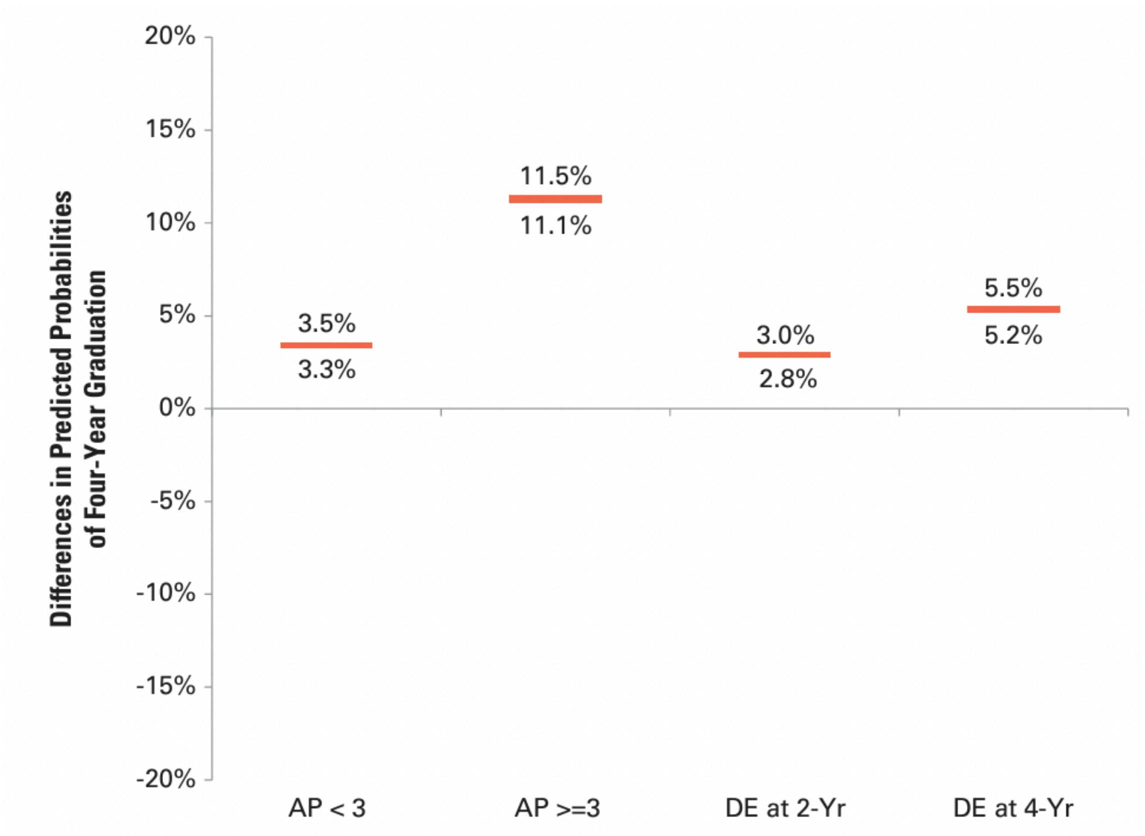


Figure 2 shows that passing AP Exams (score 3 or higher) leads to a much higher difference in the predicted probability of a four-year graduation. Ackerman et al. (2013) showed that taking AP Exams led to higher college GPAs and graduation rates. The authors indicated that average AP Exam scores were the best predictor of college success after high school GPA. With such positive benefits of taking AP courses, there is still an opportunity gap that exists. The number of Black students enrolling in AP courses across the nation is disproportionately low compared to White students and Asian students (Posselt et al., 2012; Southworth & Mickelson, 2007).

Figure 2

Differences in Predicted Probabilities of Four-Year Graduation



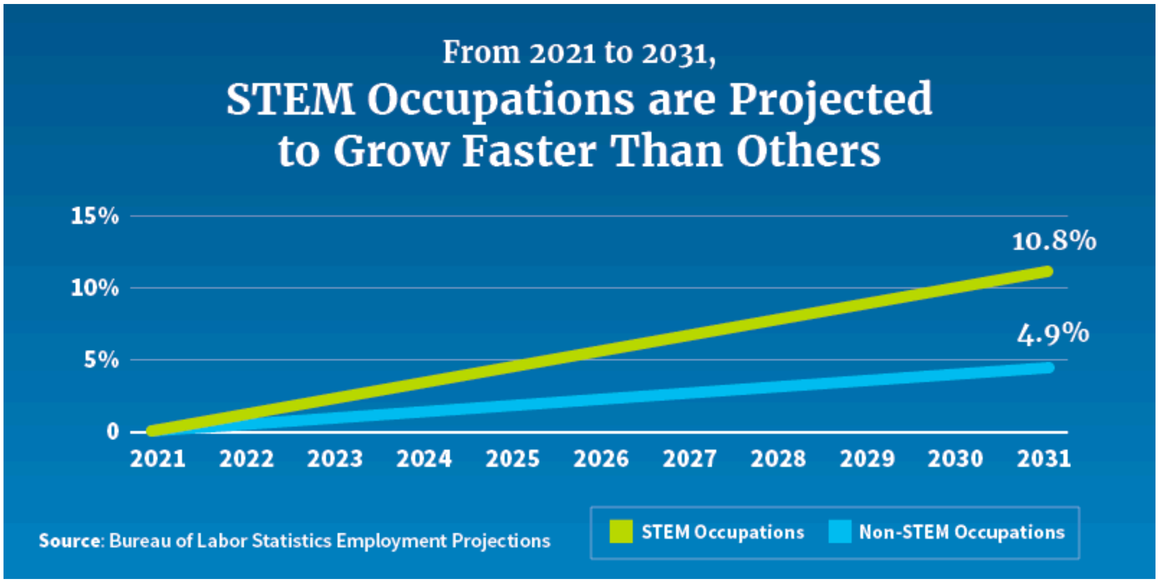
Note. AP represents AP Exam score, and DE represents Dual credit courses (College Board, 2021)

STEM Career Outlook

In terms of the education field, students have generally been told that careers in STEM will be well-paying and in abundance in the future. Recent reports have shown that the STEM job market is still growing with no signs of halting any time soon. The U.S. Bureau of Labor Statistics indicated that STEM careers are projected to grow over 10% by 2030 (Figure 3). This continued growth is 50% more than that of all other occupations (Bureau of Labor Statistics, 2021). Zilberman and Ice (2021) specifically investigated the computing field and found that this field may be in the greatest demand in the future.

Figure 3

The Growth of STEM Occupations (Krutsch & Roderick, 2022)



Krutsch and Roderick (2022) analyzed economic projections and found that job demand in ten STEM occupations will grow faster than average job demand rates while requiring only a bachelor's degree (Table 2).

It is evident from these data that STEM occupations have a positive career outlook. With many school districts focusing on ensuring students are ready for the high-needs areas in our future workforce, educators and academic organizations need to find ways to help promote diversity in these occupations. However, reducing this career gap begins with making sure that access to these areas is equitable, and students of all backgrounds are encouraged to pursue STEM degrees. Obtaining STEM degrees will open up additional career options. The opportunities to take STEM AP courses may set up students to pursue degrees and careers in STEM fields.

Table 2

Top Ten STEM Occupations with Higher Than Average Growth (Krutsch & Roderick, 2022)

Occupation	Projected Growth, 2021-2031	2021 Annual Median Pay
Data Scientist	36%	$100,910
Information Security Analyst	35%	$102,600
Statistician	33%	$95,570
Web Developer	30%	$77,030
Software Developer	26%	$120,730
Epidemiologist	26%	$78,830
Operations Research Analyst	23%	$82,360
Computer and information Research Scientist	21%	$131,490
Software Quality Assurance Analyst and Tester	21%	$98,220
Actuary	21%	$105,900

Women in Science

The role of women in scientific fields has grown tremendously, but they are still underrepresented in the STEM workforce (Martinez & Christnacht, 2021). Hall and Butler (2022) argued that one of the barriers to higher representation and general interest in science careers for women is that there is no scientific identity that is easily accessible for females. That is, while women are making significant strides in science and leading the charge in some cutting-edge research, the persona of a scientist does not seem to include women. The female identity in science is marginalized while the male identity is bolstered (Scantlebury, 2014). Ferguson and Lezotte (2020) corroborated that claim by finding that the stereotypical perception of a successful, intelligent scientist is a white, middle-aged male in a lab coat. Further, Huang et al. (2019) have shown that females' aversion and anxiety towards mathematics in their formative years seem to directly affect female interest in science and math careers. There seems to be a multi-pronged barrier that exists for females: societal pressures, stereotype threats, and internal anxiety.

Changing the Mindset

Looking at the evolution of the role of women in the workforce, trends indicate that more and more women are entering the workforce (Martinez & Christnacht, 2021). So why is there not a proportional number entering the STEM workforce? Ferguson and Lezotte (2020) showed that the mindset of a scientist did not include females to many Americans. Hall and Butler (2022) interviewed several women who were successful scientists and determined four major themes that led women to enter STEM fields and be successful. These themes were an early interest in math and science, a stubborn persistence in a science-figured world beyond school, engagement in in and shaping a science-figured world beyond school, and a positioning of themselves as science leaders. Holland et al. (1998) defined figured world as "...a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, the significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). For students, this figured world can be their classroom, other students, and shared norms. An ideal, equitable science-figured world is where females have just as active and prominent a role in science as males, both in the physical world as well as in the stereotype of a scientist.

To change the mindset and to position themselves as science leaders, women must fight to be recognized. An investigation by Guevara-Ramirez et al. (2022) identified ten rules that empowered women in STEM fields. Ultimately, it involved women taking ownership of their potential and success and not hiding in the shadows due to societal pressure. Women are achieving major accomplishments in science (such as developing the COVID-19 vaccine) but are being overshadowed or ignored due to traditional expectations. Four of the ten rules the authors propose are:

1. Avoid the Matilda Effect, which is the bias that denies providing women with the recognition they deserve.
2. Empower other women through solidarity between them: work with other women and share ideas and promote/support each other.
3. Collaboration with other scientists: work with others on complex ideas and fight to make your voice be heard.
4. Research and publish often.

The authors suggested these four rules are essential non-negotiables to help change the science-figured world that currently exists and to reshape it into one where women are equal members.

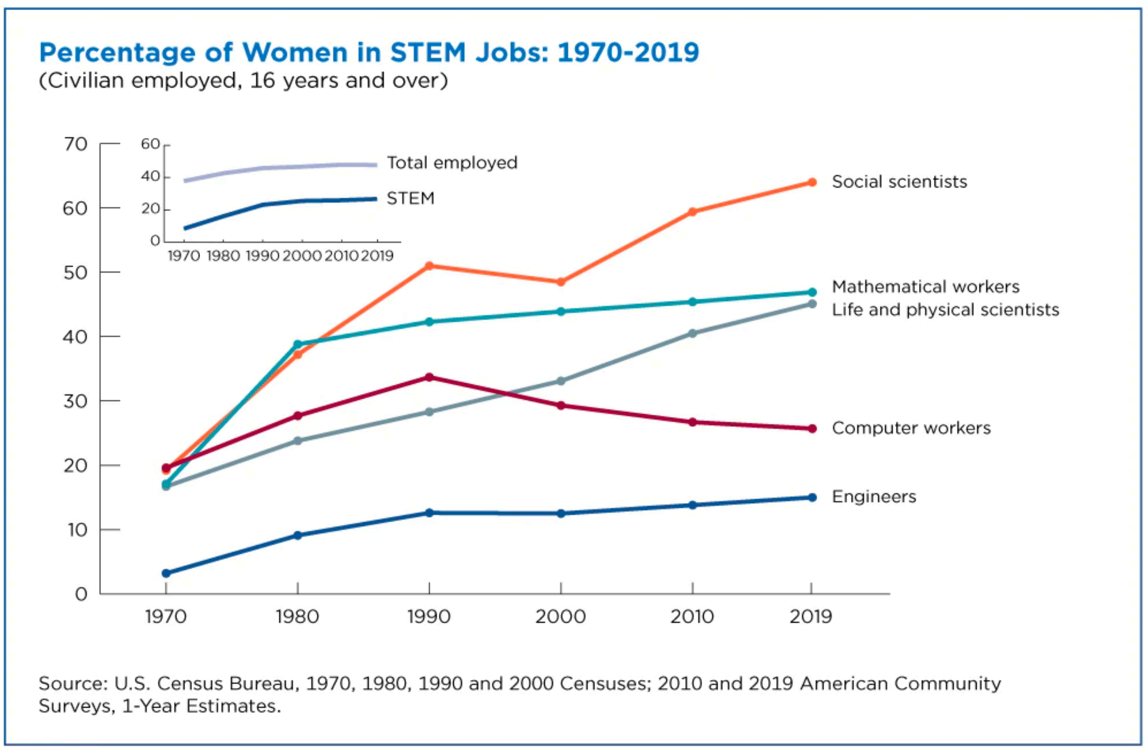
Hall and Butler's first theme (an early interest in science) directly ties into the purpose of my research study. As a high school educator, what can I do to help build and fortify this interest in science? Additionally, what can be done to help underrepresented groups be resilient in their interest in science so they can enter college to pursue STEM degrees? I hope that investigating any relationship between Advanced Placement courses and passing Advanced Placement Exams can be used to accomplish the goals of engaging underrepresented groups in high school.

The Current Workforce for Women

Looking at the current workforce, we still see that females are an underrepresented group in the STEM workforce (U.S. Bureau of Census, 2021). Figure 4 shows that women make up nearly half of the workforce but only 27% of the STEM workforce. Xu and Martin (2011) indicate that informal professional networks help maintain and advance women that are currently in STEM careers. Cronin and Roger (1999) asserted that many of the reasons that women are underrepresented in the current STEM workforce is due to a "leaky pipeline" that is progressive and persistent. This pipeline starts at grade school and continues through a person's career. The pipe leaks more the farther one moves along the pipe (progressive) and continues to leak over a long period of time (persistent). This has led to a lower representation of women in STEM careers.

Figure 4

Percentage of Women in STEM Job: 1970-2019 (Martinez & Christnacht, 2021)



Blacks in Science

The Pew Research Center conducted a survey in 2021 that showed a major underrepresentation of Blacks in science fields (Fry et al., 2021). Aside from this factor, few consider STEM professions very welcoming towards Blacks (Funk, 2022). This presents a major hurdle towards enticing and supporting Blacks to pursue degrees in the STEM fields. More importantly, this perception may be held family-wide, which then discourages grade-school students from seeing themselves in STEM careers. Funk (2022) also showed that many Blacks say they have not been encouraged to pursue sciences in high school or college. Additionally, many do not see education programs showing students how Blacks have been successful in the sciences. Many curricula emphasize Caucasian scientists and frequently mention the success of other races. This can be problematic if students cannot see themselves in future careers, they will likely fall prey to self-fulfilling prophecies and not attempt to engage in science.

Changing the Mindset

Funk (2022) used perception data to determine specific actions that can help Blacks be more likely to engage in science education and pursue STEM fields:

1. Encourage educators to foster positive personal experiences for students in the science classroom.
2. Provide mentors who can relate to the Black experience that will encourage and push students to take more rigorous courses both in general and in science content areas.
3. Educators and academic organizations should modify curricula to include Black scientists and contributions from Black scientists. The power of having high-achieving role models can be a crucial game changer.
4. Attempt to have Black instructors in the science department.

Many of the ideas represented by Funk again build support for the notion that Black students feel that a science career is out of reach which stems from their apprehension to even engage in the scientific classroom. The role of the educator can be one of the most powerful in turning the tide on this mindset.

The Current Workforce for Blacks

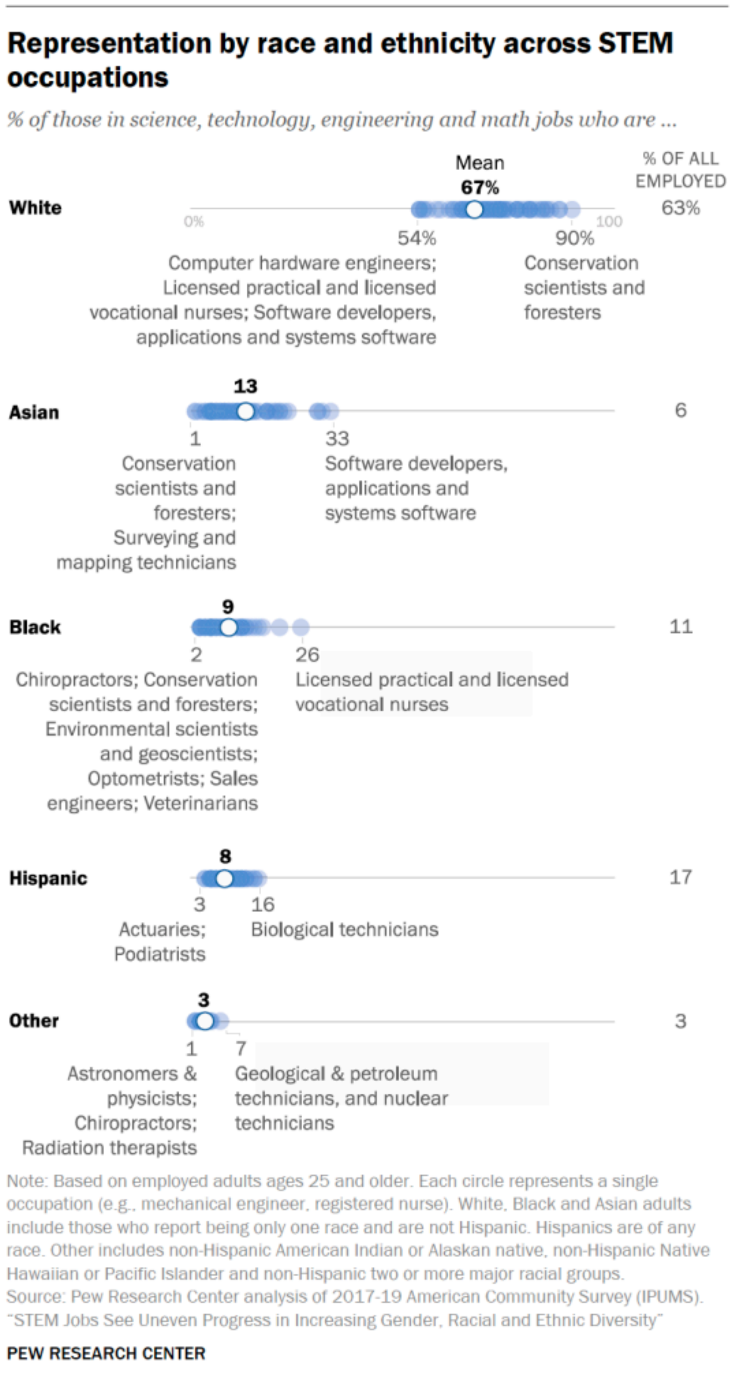
Skrentny and Lewis (2022) found that many STEM workers are often dissatisfied with non-STEM jobs; however, Blacks have an unusually higher attrition rate in STEM careers. Women, Black, and Latinx populations leave STEM education programs, change to non-STEM majors, or leave STEM career fields at a higher rate than Caucasian and Asian populations (Cech et al., 2011; Glass et al., 2013; Rosser, 2012). What could be causing this? Is it adequate preparation for the STEM jobs, self-confidence, or organizational/societal pressures? Perna et al. (2009) describe some of the themes that negatively impact the success of Blacks in reaching STEM careers:

1. Academic Preparation: there are major gaps in the STEM education programs offered in high racial minority schools.
2. Psychological Barriers
    1. Decline in self-efficacy when it comes to STEM education due to a lack of positive encouragement and learning about the success of Blacks in science.
    2. Stereotype threat: always worrying that low performance will confirm negative stereotypes.
        1. Further research shows that stereotype threat has a longstanding history of contributing to the general academic gaps between Blacks and Caucasians (Brown et al., 2000; Gonzales et al., 2002; Steele & Aronson, 1995; Whaley, 2020).

Figure 5 shows that although Blacks make up 11% of the general workforce, they only comprise 9% of all careers in STEM fields (Pew Research Center, 2021)

Figure 5

Representation of Race and Ethnicity across STEM Occupations (Pew Research Center, 2021)



Inquiry Classrooms

The science classroom has evolved as our learners have diversified and new policies have been implemented. Henson (1980) showed that throughout the second half of the 21st century, there has been a shift to making science content more uniform and meaningful for students to learn. Assessment has shifted over time as well. Common testing procedures simply emphasize the recall of scientific information rather than scientific reasoning. Teachers focus most of their time on "covering" the many required topics to get through the content (Linn et al., 2006). Additionally, educators are also being faced with higher demands, changing standards, and more day-to-day responsibilities. They are being asked to teach more content more effectively and to devote more time to having students engage in scientific practices (Edelson, 2001). Fitzgerald et al. (2019) indicated that many science teachers understand the importance of inquiry but battle the biggest barrier to its implementation: time constraints. The "fundamental objective of science education…is to enable students to observe their natural environment and to develop skills required to understand and explain both themselves and their [surroundings]" (Akinoglu, 2008, p. 220). This can be achieved through various teaching strategies that encompass direct instruction but also value the role of inquiry and modeling in the learning environment. Even guided-inquiry labs give students a better appreciation of the subject without having to spend lecture time on the material (Meuler, 2008).

A hands-on, inquiry-based design for science education potentially benefits all students (Bodzin et al., 2007). Advocates of science reform initiatives suggest that reform-based classrooms will produce learning environments that support all students to help reduce inequity in science education practices. Inquiry design helps cross-cultural, socioeconomic, gender, and racial differences in the classroom (Kang & Keinonen, 2017). Repeated opportunities to engage in scientific inquiry help students develop scientific habits of mind by understanding that science is more than memorization of ideas; it is a process and way of thinking (Windschitl & Butterner, 2000). Even student perceptions of science can be altered by using inquiry-based practices. Studies show that students have more positive attitudes toward science when teachers regularly emphasize hands-on laboratory activities and when students more frequently experience higher levels of inquiry (Ornstein, 2006). Students who learn through inquiry achieve higher grades (Chang & Mao, 1999) and participate more in class (Tretter & Jones, 2003). Classroom practices help build motivation for students to pursue science careers after high school by helping them engage in science and allowing students of all backgrounds to see themselves in the role of a scientist.

Summary

Chapter 2 has examined some of the relevant background information that will be used to support the justification for the present study. A review of essential background information regarding science in America, homework, Advanced Placement Exams, STEM career outlook, women in science, and Blacks in science has been explored to get a better picture of the present situation in America as it relates to encouraging female students and Black students to engage in science courses throughout their educational journey and pursue STEM careers. One of the major pieces of understanding from the literature review is that educators and educational entities play a large role in helping these underrepresented groups see themselves as scientists in the future. This lays the foundation for this exploration. The purpose of the current study is to explore the potential role of race and gender in science achievement. If taking Advanced Placement Exams leads to higher attainment of STEM degrees, high school teachers and counselors can take a much stronger role in encouraging students to take as many STEM AP courses as possible during their high school years. Focusing on providing specific support and encouragement will hopefully lead to greater interest and engagement in STEM careers.

CHAPTER III: METHODOLOGY

Introduction

As educators, how can we motivate more people from underrepresented groups to participate in STEM fields? The literature review indicated the impact of support, encouragement, mentorship, and role models (of the same underrepresented group) on these under-represented groups' performance in STEM courses. It has also been shown that taking advanced coursework such as AP courses in high school eases the discomfort that many students (including underrepresented groups) feel when thinking about careers in STEM. This present investigation of existing data will focus on science achievement. The purpose of the current study was to explore the role of taking AP Exams, race, and gender in science achievement. Science achievement is defined as STEM degree attainment. Because this investigation relies solely on existing data from the institutional database of a regional university, there is not any interaction with participants directly nor is there real-time data collected. This is purely a quantitative design exploration of data to draw conclusions if possible.

Research Questions

The research questions are formally stated below.

- Research Question 1
  - Is there an association between having Advanced Placement Exam College Credit (AP) and Time to Graduation?
    - The null hypothesis (H_0): there is no association between having AP Exam College Credit and Time to Graduation. H_0: $\rho = 0$.
    - The alternative hypothesis (H_a): there is a negative association between having AP Exam College Credit and Time to Graduate. H_a: $\rho < 0$.

- Research Question 2
    - 2a: Is there a statistically significant difference in the first-year college GPA of <u>all students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?
        - The null hypothesis (H_0): mean first-year college GPA is not significantly different between students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2). H_0: $\mu_1 = \mu_2$.
        - The alternative hypothesis (H_a): mean first-year college GPA is lower for all students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2). H_a: $\mu_1 < \mu_2$.
    - 2b: Is there a statistically significant difference in the first-year college GPA of <u>Black students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?
        - The null hypothesis (H_0): mean first-year college GPA is not significantly different between Black students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2). H_0: $\mu_1 = \mu_2$.
        - The alternative hypothesis (H_a): mean first-year college GPA is lower for Black students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2). H_a: $\mu_1 < \mu_2$.
    - 2c: Is there a statistically significant difference in the first-year college GPA of <u>female students</u> between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit?

- The null hypothesis (H_0): mean first-year college GPA is not significantly different between female students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2). H_0: $\mu_1 = \mu_2$.
- The alternative hypothesis (H_a): mean first-year college GPA is lower for all female students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2). H_a: $\mu_1 < \mu_2$.

- Research Question 3
  - Which of the predictor variables (passing STEM Advanced Placement Exams, first-year GPA, gender, and race) are associated with the likelihood of graduating with a STEM degree?
    - The null hypothesis (H_0) is that there is no difference in the odds ratio of passing STEM Advanced Placement Exams (β_1), first-year college GPA (β_2), gender (β_3) and race (β_4) and earning a STEM degree. H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$.
    - The alternative hypothesis (H_a) is that $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$.
    - The full model is:

  Logit $[\pi(x)] = \beta_0 + \beta_1$ (passing STEM Advanced Placement Exams) + β_2 (first-year college GPA) + β_3 (gender) + β_4 (race)

A 95% confidence interval will be used for the current study. The null hypothesis can be rejected at $p < 0.05$.

Research Design

The study incorporates a quantitative, correlational analysis. The data obtained is considered a primary source since it is obtained in raw format. Analysis of the raw data will lead to making interpretations that can be used to provide insight on the three research questions. The data come from databases and were collected by other investigators/organizations, so the data are considered secondary data. Thus, the research design uses primary source, secondary data methodology. Because participants were chosen simply based on inclusion criteria at a specific point in time, this investigation has a cross-sectional study design (Wang & Cheng, 2020). This type of study focuses on studying a population for descriptive research. The goal of this type of design (as opposed to longitudinal) is not to find exact cause and effect relationships but to make inferences about potential relationships between variables. Therefore, a cross-sectional study design is most appropriate for the study. The ability to look at several characteristics at once can help make inferences and pose questions for later, more detailed studies.

Setting and Participants

For the research questions, data from a local university were the only source of data analyzed. This university is located in a small suburban city. The university is the third largest in the state of Kentucky. The academic institution is a comprehensive, regional university offering bachelor's, master's, and doctoral degrees. As a regional university, the population of the school often comes from the surrounding region, although there is a directed emphasis on inviting international students. Because of its regional status, the population and culture may be similar to that of the surrounding communities. Data obtained for all of the research questions solely included students who began their first semester at the university between Fall 2012 through Fall

2017 (with a graduation by Spring 2023). Only first-time, full-year, full-time students were considered (*N* = 19,568); transfer students were not included. The reason why this time frame was chosen was to allow for a student starting between Fall 2012 through Fall 2017 to have a traditionally accepted six-year graduation period (NCES, 2022). The longer time span also allowed for a gap due to the COVID-19 pandemic. The data were obtained from the university in Summer 2022 and updated in Fall 2023. The data obtained from the university did not have any student identifiers; only the requested data were provided. It is important to note that several pieces of data provided by the university had to be eliminated since it did not meet the inclusion criteria for the current study. For example, students who did not indicate a race or gender (or preferred not to answer) were removed from the data before analysis. Additionally, students who started at the university but did not graduate were also excluded from the analysis, as they did not fit the criteria of having a graduation year.

The identifiers for underrepresented groups used in the present study were based on gender and race. For the College Board data as well as the university institutional data, gender and race for each data point are as indicated by the organizations. Information regarding the biological sex of the individual was not obtained. A participant is assigned to a group based on what they indicated on the organizational database whether it was their sex or preferred gender. This is also the case for race related data as well. Only self-reported race is considered for the current study.

In the complete dataset, there were 19,568 participants (Male = 8,613, Female = 10,955, White = 14,124, Black or Black = 2,703). Only 9,860 of these participants graduated from the university within the specified time period (Male = 3,880, Female = 5,980, White = 7,943, Black or Black = 680).

Data Acquisition

A data set was used to analyze the three research questions of the study. The dataset contained information about the student population at a regional university offering a variety of degrees. In total, de-identified information for over 19,000 students was obtained. Several obtained data points had to be removed because the data received was incomplete or did not include the relevant information needed for the present study.

Obtaining the actual data for the research questions was much easier than attempting to request data from the College Board. This dataset solely involved students at a local, regional university who began enrollment in Fall 2012 through Fall 2017 as first-time, full-year, full-time students. This is six cohorts at a traditionally accepted six-year graduation rate (keeping in mind that the COVID-19 pandemic may have affected some graduations). The actual number of semesters it took a participant to graduate was also analyzed in the current study. In order to access this information, Institutional Research at the regional university was contacted; a request was made for the specific information needed for this investigation. IRB Approval can be found in Appendix A. The data set requested suppressed any connection to identify a student (e.g., name, birth date, social security number, and school ID number). The received data file was an aggregate of raw data with information of 19,568 participants. The final updated data was obtained in Fall 2023, so it included data of Spring 2023 graduates. The data requested from Institutional Research at the regional university (also see Appendix B) can be found below.

- Cohort requested: start Fall 2012 through Fall 2017; first-year, full-year, full-time only; graduate by Spring 2023
- Gender
- Race

- First-Year College GPA
- College Graduating GPA
- Advanced Placement Exam Taken (Yes/No)
- Total Number of AP Exams Passed (Score of 3, 4, or 5)
- AP Biology Score
- AP Chemistry Score
- AP Calculus Score (AP Calculus AB or AP Calculus BC)
- AP Statistics Score
- Any AP Physics Score (AP Physics 1, AP Physics 2, AP Physics C: Mechanics, AP Physics C: Electricity and Magnetism)
- Enrollment Term (this was used to determined semesters needed to graduate)
- Graduation Term (this was used to determined semesters needed to graduate)
- In what Major was a Degree Earned
- STEM Degree Earned: Biology, Chemistry, Engineering, Geology, Mathematics, Physics (Yes/No)

Data obtained from Institutional Research at the university did not differentiate between sex and gender nor did it have separate values for race and ethnicity. Thus, data indicated in tables and figures from the data analysis software may use sex and gender synonymously as well as have combined race and ethnicity. Due to the clear distinction between these terms within the scope of the current study, the written portions of this dissertation will use gender rather than sex and race rather than ethnicity. Additionally, Institutional Research did not provide data regarding College Graduating GPA nor Total Number of AP Exams Passed. All other information was provided and used directly or indirectly in analysis.

Data Cleansing

Data provided by Institutional Research at the regional university arrived in a Microsoft Excel data file document. After importing the data into SPSS, several cleansing steps took place to make the data available for direct analysis.

Time (Semesters) to Graduate

The raw data from Institutional Research did not provide a value that directly corresponded to the time to graduate (in semesters). Instead, information was given regarding the enrollment term and graduation term. The data was in the format XXXXYY. The XXXX corresponds to the calendar year, and the YY corresponds to the term (term and semester will be used interchangeably) within that calendar year. The possible terms were Spring (YY=10), Summer (YY=20), and Fall (YY=30). As an example, a student who enrolled in term 201530 means that they enrolled in the Fall (YY=30) of 2015 (XXXX=2015). This formatting made it difficult to easily determine the time of graduation as there was not a linear relationship between the term code and the semesters (due to the change in YYYY year every three XX terms). To resolve this, the terms were recoded into new variables. The entire data set spanned between the earliest enrollment term of 201230 (Fall 2012) and the latest graduation term of 202310 (Spring 2023). The first term (201230) was recoded as Semester 1. Each subsequent term was recoded as Semester 2, 3, 4, and so on. The final term (202310) was Semester 32. Each enrollment term was recoded into a semester number and each graduation term was recoded into a semester number. With this new coding system in place, a Time to Graduation (in semesters) could be calculated using the following formula:

Semesters to Graduate = (Graduation Semesters – Enrollment Semester) + 1

As an example, a student who starts in the Fall of 2012 (201230) and graduates in the Spring of

2016 (201610) will have their Enrollment Term as Semester 1 and their Graduation Term as Semester 11. Using the equation above, the time to graduate = (11-1) + 1 = 11 semesters.

Numeric Conversion

During the import to SPSS, several data values were added as string values. This required the recoding of these variables into numeric values, so SPSS could read the values correctly and perform the appropriate tests. The following fields provided by Institutional Research needed to be recoded into numeric values: Sex, Ethnicity, Specific AP Exam Scores (Biology, Chemistry, Calculus, Statistics, Physics), Any AP Taken, and STEM Degree Earned.

Passing a STEM AP Exam

An important variable to the present study is determining whether an individual passed at least one STEM AP Exam. The data file received from Institutional Research did not directly include this information. It included student scores if they took any of the following AP STEM Exams: AP Biology; AP Chemistry; AP Calculus (AP Calculus AB or AP Calculus BC); AP Statistics; or AP Physics (AP Physics 1, AP Physics 2, AP Physics C: Mechanics, or AP Physics C: Electricity and Magnetism). A score of 0-2 indicated not passing the exam, while a score of 3-5 indicated passing the exam. In order for SPSS to have the correct variable to analyze (passing any STEM AP exam or not), the data needed to be recoded. As mentioned above, the AP Exam data for each test was first converted from string to numeric. Next, each STEM AP Exam was recoded as 0 if the student did not pass the exam (score of 0-2 or they did not take the exam) or recoded as 1 if the student passed the exam (score of 3-5). This results in a 0 or 1 value for each STEM AP Exam. Since the study was only interested in if the individual passed at least one exam, another data transformation was needed. Next, a new data value was calculated which was a sum of the recoded STEM AP Exam data which indicated how many STEM AP Exams a student passed. Finally, another transformation allowed for determining if at least one STEM AP Exam was passed by recoding the summed AP Exam data as simply a 0 if no STEM AP exams were passed or a 1 if at least one STEM AP Exam was passed.

Data Analysis

Once the requested data were collected, they were analyzed using a standard statistical software. The data were obtained either as an Excel spreadsheet file or a CSV data file. The data was then imported into the IBM SPSS (Version 29.0.1.0(171)) software for analysis.

Before any analysis could occur, approximately 9,000 data points were removed that did not fit the inclusion criteria (about 50% of the original data). Research Questions 1-3 depended on the participant graduating (and thus earning a degree), so participants who dropped out of the university, transferred out of the university, or had not graduated by Spring 2023 were removed from the data. The available data for these participants would not be helpful in exploring the research questions. Since no investigations on the direct interaction of race and gender were being studied, it was not necessary to remove participants from the entire study if they only provided one of these two pieces of information. Participants who did not indicate a gender were removed from the data set when conducting the gender investigations, but those participants were left in for race investigations if they did indicate a race. Participants who did not indicate a race were removed from the data set when conducting the race investigations, but those participants were left in for gender investigations if they did indicate a gender.

After preliminary examination and data cleansing on the raw data, one dataset containing the regional university data with all participants who graduated within the indicated timeframe and provided a gender response of male or female on their university profile was created in case a solely gender-focused dataset was needed. A second dataset also utilized the regional university data with all participants who graduated within the indicated timeframe and provided a race response of something other than "Prefer not to Answer" on their university profile in case a solely race-focused dataset was needed. These data sets were created implicitly within the analysis software by using specific cases (such as only those who provided a race response of the groups of interest) in the data analysis.

The IBM SPSS software (Version 29.0.1.0(171)) was used to perform statistical tests. A coding system was created to convert some of the raw data into a usable format for SPSS analysis. When looking at whether a STEM Degree was earned, a code value of zero was given to "no STEM Degree earned," and a code value of one was given to "STEM Degree earned." The type of variable and measurement level (e.g., dichotomous, continuous, ordinal, or ratio) and desired purpose for each Research Question was considered when determining which statistical test was the most appropriate to utilize.

Research Question 1. An association between AP Exam College Credit earned and graduation time was investigated. The dependent variable was dichotomous (earned AP Exam College Credit or not) while the independent variable was continuous (semesters until graduation). A Point-Biserial Correlation Test was initially considered in order to describe this correlation. However, the test was not conducted due to the independent variable (semesters until graduation) failing the normality test. This means that one of the assumptions of the Point-Biserial Correlation Test was not met (see Limitations section). Instead, a Spearman's rank-order correlation test was conducted. This test is considered a nonparametric equivalent to the Point-Biserial Test (Spearman's Rank-Order Correlation in SPSS Statistics, 2018).

Research Question 2. A statistical difference in GPA was investigated between two groups using means testing. Three separate sub-questions make up this research question, as different populations are being described. In each analysis, the independent variable was categorical (nominal) with two options (earned AP Exam College Credit or not). The group difference (criterion variable) was investigated by looking at mean first-year college GPA. An independent sample *t*-test was used to determine if statistical differences existed between the investigated groups. The three populations investigated were (1) all students, (2) only Black students, and (3) only female students. However, the independent sample *t*-test was not conducted due to first-year GPA not being normally distributed as the test for normality was not met. This violates one of the assumptions for a *t*-test (see Limitations section). Instead, a Mann-Whitney *U* Test was conducted. This test is considered a nonparametric equivalent to the independent sample t-test (Mann-Whitney *U* Test in SPSS Statistics, 2018).

Research Question 3. The influence of various factors (gender, race, first-year college GPA, and passing STEM AP Exams) on STEM Degree Attainment (earning a STEM degree) was explored. The independent variable factors investigated were either dichotomous or continuous, while the dependent variable was dichotomous. A multiple logistic regression analysis was utilized to evaluate these relationships.

For large sample sizes, the minimum sample size needed can be determined by: N = 100 + 50*i* where *i* refers to the number of independent variables in the full model (Bujang et al., 2018). The full model contains four independent variables, so the minimum sample size is 700 which is below the sample size used in the current study.

Codebook

After the data cleansing and recoding, data in the SPSS system was analyzed using the appropriate statistical tests for each research question. When reading the outcome tables from each test on SPSS, it is essential to understand what the coded values represent. Table 3 indicates the codes used in this design (also see Appendix C).

Table 3

Codebook of Variables of Interest to the Current Study

Description	Variable	Label	Values	Measure
Reported Gender of Individual	Sex_New	Gender New	0 = Male 1 = Female 99 = Other Responses	Nominal
Reported Race of Individual	Ethnicity_New	Ethnicity New	0 = White 1 = Black or Black 99 = Other Responses	Nominal
First Year Grade Point Average	COLL_GPA	1st Yr GPA	[0, 4.00]	Scale
Number of semesters taken to graduate	Semesters_to_ Graduate	Semesters to Graduation	[1, 32]	Scale
Taking any AP Exams regardless of content area and score	AP_Taken_New	AP Taken New	0 = No 1 = Yes	Nominal
Passing at least one STEM AP Exam (score of 3-5)	STEM_AP_ Passed	STEM AP Passed	0 = No 1 = Yes	Nominal
Earning at least one STEM BA/BS degree	STEM_Degree_ Earned_New	STEM Degree Earned	0 = No 1 = Yes 9 = No degree earned (did not graduate)	Nominal

Note: Variable and Label indicate data headings in SPSS. See comments in the Data Acquisition section regarding sex/gender and race/ethnicity terminology.

Ethical Considerations

The data used in the present study were obtained in the form of raw data from an educational institution (a regional, four-year university offering a variety of degree programs). All of the data requested were directly related to this study. Additionally, no personally identifying information was requested such as name, birth date, student ID number, social security, or any other characteristic that can be used to identify a specific individual. Because no data could identify a student, participant privacy is not a necessary consideration for the current study. The data requested from the organizations will be used according to their acceptable use policies.

Limitations

The long-term goal of the present study is to identify a controllable intervention that can be used in high school with underrepresented groups that would encourage them to pursue STEM degrees and careers in order to create a more representative STEM workforce. School administrators, teachers, staff, and culture providing the appropriate environment of academic and emotional support can lead to underrepresented group students being more likely to pursue STEM degrees (as shown in the literature review). A greater number of these groups entering college and earning STEM degrees can lead to greater opportunities to fill the growing number of STEM careers (which come with a higher salary). This path leads to a more diverse STEM workforce with individuals having a higher level of income which can encourage greater social mobility for underrepresented families. This is an essential component of Critical Race Theory. In order to have such lofty long-term implications of this research, it is important to understand the limitations that were present.

Population

The population used in the current study is a regional university that typically fields students from the local area of its small city and rural Kentucky. Thus, the diversity in the population may not be indicative of the diversity represented nationwide or in a typical grade school-wide setting (across the nation). Understanding the complexities of cultural conditions as well as community or societal expectations for a neighborhood or region can easily impact the outcome of the research. So, understanding the chosen population is necessary in order to frame the community that is represented with these data.

COVID-19 Pandemic

The COVID-19 pandemic affected students in the middle of the timeframe chosen for the current study. The university shifted to a virtual format of education in order to limit exposure to students. This shift to virtual platforms may have had negative impacts on student success in these courses potentially impacting GPAs and time needed to graduate (Engelhardt et al., 2023).

Achievement Parameters

Science achievement can have varying criteria for many people. In the present study, passing STEM Advanced Placement Exams (score of 3 or higher) and earning STEM degrees was a criterion for success. The data provided only gives information on students who have earned STEM degrees. It does not tell me about students who started with a STEM degree but then changed majors. There is also a major assumption that all students had equal access to STEM Advanced Placement programs at their high schools. While this is definitely not the case as Advanced Placement programs are waning, it is difficult to analyze which students had this opportunity.

Statistical Tests

Statistical tests used in the present study come with a set of assumptions that make their outcomes valid. The assumptions for each test are listed below.

- Point-Biserial Test: One variable must be continuous, while the other must be dichotomous. There should be no outliers for the continuous variable. The continuous variable should be approximately normally distributed. The continuous variable should have equal variances (Point-Biserial Correlation in SPSS Statistics, 2018).
- Spearman's Rank-Order Correlation Test: The test is appropriate for data that has variables that are ordinal, interval, or ratio. The variables should be representative of a single participant (paired observations). A monotonic relationship between variables is needed. (Spearman's Rank-Order Correlation in SPSS Statistics, 2018).
- Independent Sample t-Test: The group variable should be continuous, while the independent variable should be two categorical groups. There should be independence of observations (no relationship between observations in the group and the group itself). There should be no outliers, the grouping variable should be about normally distributed, and there should be a homogeneity of variances (Independent t-test in SPSS Statistics, 2018).
- Mann-Whitney *U* Test: The group variable should be ordinal or continuous, while the independent variable should be two categorical groups. There should be independence of observations (no relationship between observations in the group and the group itself). The variables do not have to be normally distributed but the distributions must have the same shape (Mann-Whitney *U* Test in SPSS Statistics, 2018).
- Binomial Logistic Regression: The grouping variable should be dichotomous, while the

independent variables can be continuous or categorical. There should be independence of observations, the grouping variable should have mutually exclusive categories, and there should be a "linear relationship between any continuous independent variables and the logit transformation of the dependent variable" (Binomial Logistic Regression in SPSS Statistics, 2018).

Delimitations

Some delimitations of the study include that the STEM degrees are specific disciplines that I have chosen: Biology, Chemistry, Engineering, Geology, Mathematics, Physics. Gender is based on what students identified as on their admission application to this regional university. Finally, the COVID-19 pandemic impacted educational institutions, Advanced Placement Exams, as well as the general student educational process. Results will be presented as if there were no COVID interruptions. Quantifying the impact that the pandemic had on specific groups is difficult.

Summary

This chapter described the methodology utilized in the research study. Overall, a quantitative method approach is followed using data from existing databases of educational institutions at a regional university. The setting, participants, data acquisition, data analysis, ethical considerations, and limitations were discussed in detail. Each statistical method was described along with its related assumptions. Finally null and alternative hypotheses were proposed for each research question. These guidelines were put in place as the data analysis step began in order to see if any relationships exist between underrepresented groups (considering gender and race) and science achievement (Advanced Placement Exam scores and STEM degree attainment). The binomial logistic regression allowed for predictors of success based on a variety of factors (passing STEM AP Exams, first-year college GPA, gender, and race). The following chapter will provide the results of the data analysis.

CHAPTER IV: RESULTS

Introduction

Chapter 4 presents results from the analysis of the acquired data in reference to the research questions. Raw data, provided by Institutional Research from a regional university, were imported into the IBM SPSS program (Version 29.0.1.0(171)). Data were transformed into formats and values that could be utilized for conducting specific statistical tests as indicated in the methodology. Chapter 4 is organized as follows: the first section will provide descriptives of the dataset and the second section will drill into the research questions through inferential statistics.

Descriptive Statistics

Table 4 presents descriptives of the entire dataset. Descriptives for gender (*M* = 0.56, *SD* = 0.496, *Mdn* = 1, *Mode* = 1) indicate that there were more females than males in the dataset. For race, the median and mode values are both 0 indicating that the majority of students in the dataset were White. The AP Exam Taken descriptives (*M* = 0.31, *SD* = 0.462, *Mdn* = 0, *Mode* = 0) indicate that the majority of students attending this regional university did not enter college with any AP Exams taken (and reported to the university). For STEM AP Exam Passed (*M* = 0.06, *SD* = 0.236, *Mdn* = 0, *Mode* = 0), results showed that the majority of students attending this university do not enter with a passed AP STEM Exam. The mean of passing AP STEM Exams (0.06) being lower than the mean of passing any AP Exams (0.31) shows that, as expected, not all students entering the university with AP credit had earned AP STEM credit. The descriptives for STEM Degree Earned show a mode value of 9 indicating that more students in the dataset did not earn any degree than those who did a STEM or non-STEM degree. However, the median value of 1 indicates that more than half of the participants in the dataset earned some type of degree. First-year Grade Point Average (GPA) was measured on a scale (*min* = 0, *max* = 4.00). For the missing observation value, 2,072 students who enrolled did not complete their first year. The mean GPA of 2.79 indicates that students had an average letter grade between a B and C for all of their numeric, credit-bearing courses in their first year. A mode value of 4.00 indicates that for all students, more students had a perfect GPA than any other GPA value. The Semesters to Graduation variable ranges from a minimum of five semesters to a maximum of 32 semesters. A typical four-year graduation would span 11 semesters (summer semesters included). The missing observations show that 9,708 of enrolled students did not graduate, which is roughly 49.6% of enrollments. The mean value of 12.24 and median/mode values of 11 represent that most students graduate very close to the typical four-year graduation period.

Table 4

Descriptive Statistics for the Acquired Dataset

Statistics

		Gender New	Ethnicity New	AP Taken New	STEM AP Passed	STEM Degree Earned	1st Yr GPA	Semesters to Graduation
N	Valid	19568	19568	19568	19568	19568	17496	9860
	Missing	0	0	0	0	0	2072	9708
Mean		.56	14.01	.31	.06	4.52	2.7859	12.24
Median		1.00	.00	.00	.00	1.00	3.0000	11.00
Mode		1	0	0	0	9	4.00	11
Std. Deviation		.496	34.306	.462	.236	4.449	.98263	2.580
Skewness		-.241	2.074	.829	3.727	.008	-.969	2.116
Std. Error of Skewness		.018	.018	.018	.018	.018	.019	.025
Kurtosis		-1.942	2.302	-1.312	11.892	-1.992	.329	7.741
Std. Error of Kurtosis		.035	.035	.035	.035	.035	.037	.049
Minimum		0	0	0	0	0	.00	5
Maximum		1	99	1	1	9	4.00	32

Inferential Statistics

The purpose of Research Question 1 was to determine if there is an association between having Advanced Placement Exam College Credit and Time to Graduation as measured by the number of semesters taken to graduate.

The null hypothesis (H_0) is that there is no association between having AP Exam College Credit and time required to graduate:

$$H_0 : \rho = 0.$$

The alternative hypothesis (H_a) is that there is an association between having AP Exam College Credit and time required to graduate:

$$H_a : \rho \neq 0.$$

To investigate this question, a Point-Biserial Correlation Test was initially considered to describe this correlation. However, the Semesters to Graduation variable failed the normality test, so the non-parametric equivalent of this test was needed. A Spearman's rank-order correlation test was conducted to investigate any association between these variables. For students who took an AP Exam, the mean time taken to graduate was 11.73 semesters (*Mdn* = 11.00). For students who did not take an AP Exam, the mean time taken to graduate was 12.64 semesters (*Mdn* = 12.00). Analysis showed a negative correlation between having Advanced Placement Exam College Credit and Time to Graduation, which is statistically significant (ρ (9788) = -0.205, p = < 0.001; Table 5). This indicates that as AP Exam College Credit increases, there is a decrease in the number of semesters needed to graduate. This result supports the rejection of the null hypothesis (H_0) in favor of the alternative hypothesis (H_a).

Table 5

Research Question 1 Analysis using Spearman's Rank-Order Correlation

Correlations

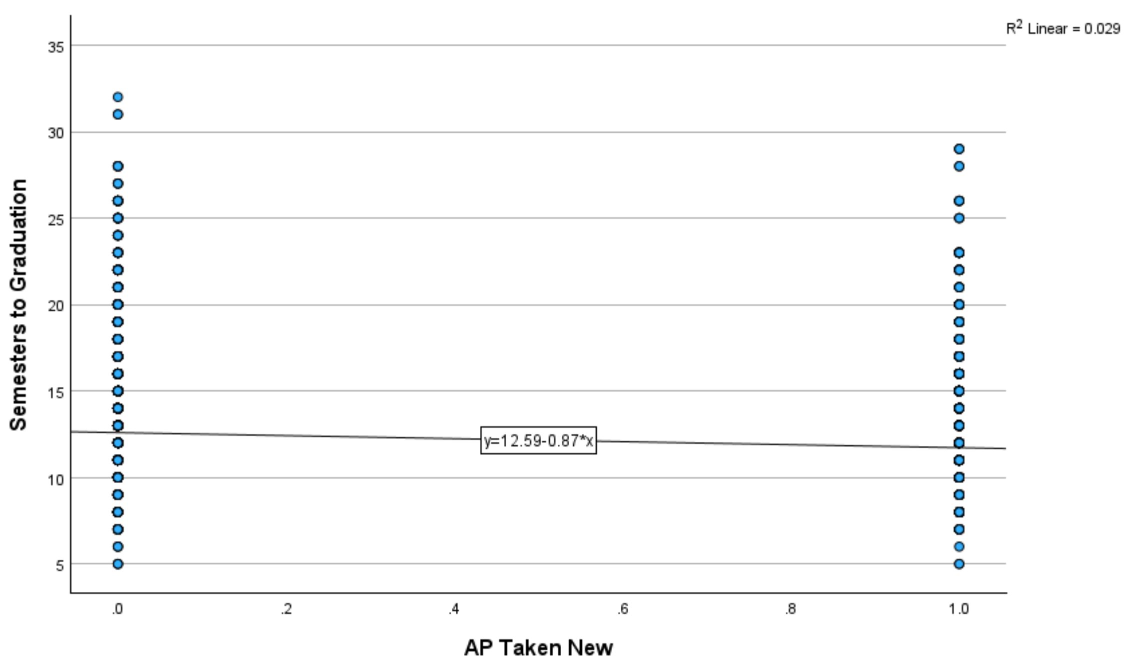
			AP Taken New	Semesters to Graduation
Spearman's rho	AP Taken New	Correlation Coefficient	1.000	-.205**
		Sig. (1-tailed)	.	<.001
		N	17496	9790
	Semesters to Graduation	Correlation Coefficient	-.205**	1.000
		Sig. (1-tailed)	<.001	.
		N	9790	9790

**. Correlation is significant at the 0.01 level (1-tailed).

Figure 6 displays a graphical representation of the results from the Spearman's rank-order correlation test. In this sample, the results indicate that as a student moves from not taking AP to taking AP, the number of semesters to graduation decreases.

Figure 6

Research Question 1 Analysis using Spearman's Rank-Order Correlation



Research Question 2a for the present study was designed to determine if there is a statistically significant difference in the first-year college GPA of all students between those who have earned Advanced Placement Exam College Credit and those who have no AP Exam College Credit.

The null hypothesis (H_0) is the mean first-year college GPA is not significantly different between all students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2):

$$H_0 : \mu_1 = \mu_2$$

The alternative hypothesis (H_a) is the mean first-year college GPA is lower for all students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Exam Credit (μ_2):

$$H_a : \mu_1 < \mu_2$$

To investigate this question, an independent sample *t*-test was initially considered to describe any differences. However, the first-year GPA variable failed the normality test. GPA was standardized to provide equal representation across the values, but it still failed the assumptions of the *t*-test. A non-parametric equivalent of this test was needed. A Mann-Whitney *U* test was conducted to investigate differences in means of these variables. A Mann-Whitney *U* test was performed to evaluate whether first-year GPA differed between all students who had earned AP Exam College Credit and those who did not.

The results indicate that, when considering all students, those who did have AP Exam College Credit had significantly higher first-year GPAs (Mdn = 3.48, n = 5768) than the first-year GPAs (Mdn = 2.75, n = 11728)) of those students who did not have AP Exam College Credit (U = 49685737.5, p = < 0.001; with a small to medium effect size r = 50.513/sq root

17496 = 0.38; Table 6). This allows for the rejection of the null hypothesis (H_0) that there is no difference in first-year GPA for all students between having AP Exam College Credit or not in favor of the alternative hypothesis (H_a).

Table 6

Research Question 2a Analysis using Mann-Whitney U Test

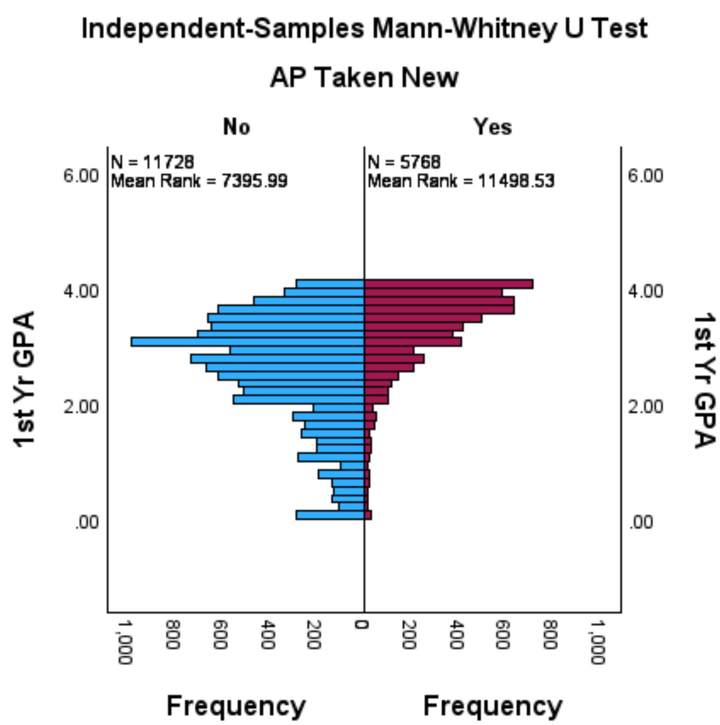
Independent-Samples Mann-Whitney U Test Summary

Total N	17496
Mann-Whitney U	49685737.500
Wilcoxon W	66323533.500
Test Statistic	49685737.500
Standard Error	314023.639
Standardized Test Statistic	50.513
Asymptotic Sig.(2-sided test)	<.001

Figure 7 shows a difference in the ranked sum of the two groups. The mean rank for the GPA for all students who had not taken an AP Exam is 7,396, while the mean rank for the GPA for all students who had taken an AP Exam is 11,499. The figure also shows that students who had taken an AP Exam had a greater concentration of GPA values closer to 4.00 than those who did not take AP Exams.

Figure 7

Research Question 2a Analysis using Mann-Whitney U Test



Research Question 2b for the present study was written to determine if there is a statistically significant difference in the first-year college GPA of Black students between those who have earned Advanced Placement Exam College Credit and those who have no AP Exam College Credit.

The null hypothesis (H_0) is the mean first-year college GPA is not significantly different between Black students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2):

$$H_0 : \mu_1 = \mu_2$$

The alternative hypothesis (H_a) is the mean first-year college GPA is lower for Black students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2):

$$H_a : \mu_1 < \mu_2$$

To investigate this question, an independent sample *t*-test was initially considered to describe any differences. However, the first-year GPA variable failed the normality test. GPA was standardized to provide equal representation across the values, but it still failed the assumptions of the *t*-test. A non-parametric equivalent of this test was needed. A Mann-Whitney *U* test was conducted to investigate differences in means of these variables. A Mann-Whitney *U* test was performed to evaluate whether first-year GPA differed between Black students who had earned AP Exam College Credit and those who did not.

The results indicate that, when considering <u>Black students</u>, those who did have AP Exam College Credit had significantly higher first-year GPAs (*Mdn* = 2.80, *n* = 248) than the first-year GPAs (*Mdn* = 2.05, *n* = 2008) of students who did not have AP Exam College Credit (U = 346781.0, p = < 0.001; with a small effect size r = 10.105/sq root 2256 = 0.21; Table 7). This allows for the rejection of the null hypothesis (H_0) that there is no difference in first-year GPA for <u>Black students</u> between having AP Exam College Credit or not in favor of the alternative hypothesis (H_a).

Table 7

Research Question 2b Analysis using Mann-Whitney U Test

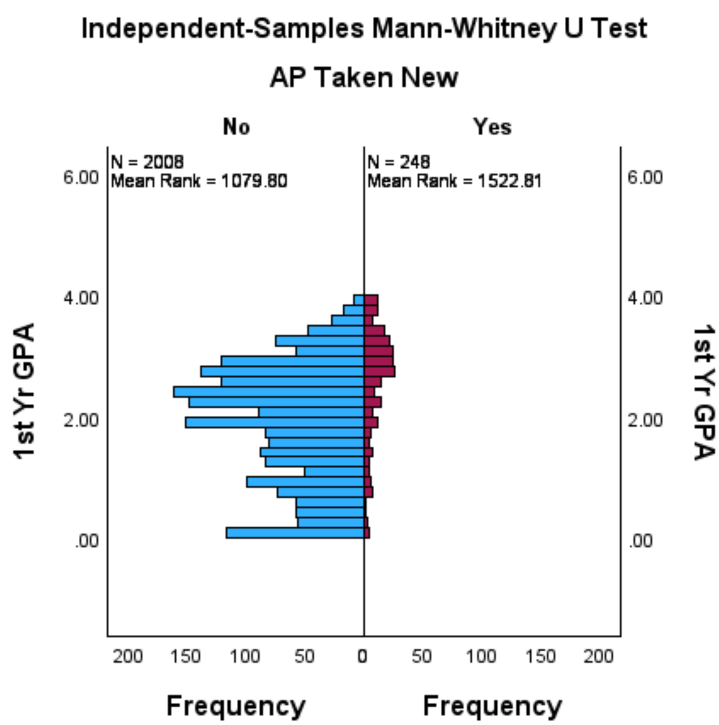
Independent-Samples Mann-Whitney U Test Summary

Total N	2256
Mann-Whitney U	346781.000
Wilcoxon W	377657.000
Test Statistic	346781.000
Standard Error	9676.899
Standardized Test Statistic	10.105
Asymptotic Sig.(2-sided test)	<.001

Figure 8 shows a difference in the ranked sum of the two groups. The mean rank for the GPA for Black students who had not taken an AP Exam is 1,080, while the mean rank for the GPA for Black students who had taken an AP Exam is 1,523. The figure also shows that Black students who had taken an AP Exam had a greater concentration of GPA values closer to 4.00 than those who did not take AP Exams.

Figure 8

Research Question 2b Analysis using Mann-Whitney U Test



Further investigation into the Black population was conducted to gather a more complete picture of this group. Table 8 shows descriptive statistics on the population. This analysis indicates an important observation related to the current study: Mean GPAs of Black students. Those students in this group who had not taken any AP Exam had a mean first-year GPA of 1.9078 (below a C average). Black students who had taken at least one AP Exam had a mean first-year GPA of 2.5585 (mid-C average). The median GPA is higher for those who had taken an AP Exam (2.80) than those who had not (2.05).

Table 8

Descriptive Statistics of Black Students in relation to first-year GPA and taking AP Exams

Descriptives

	AP Taken New			Statistic	Std. Error
1st Yr GPA	No	Mean		1.9078	.02182
		95% Confidence Interval for Mean	Lower Bound	1.8650	
			Upper Bound	1.9506	
		5% Trimmed Mean		1.9218	
		Median		2.0450	
		Variance		.956	
		Std. Deviation		.97759	
		Minimum		.00	
		Maximum		4.00	
		Range		4.00	
		Interquartile Range		1.50	
		Skewness		-.299	.055
		Kurtosis		-.820	.109
	Yes	Mean		2.5585	.05939
		95% Confidence Interval for Mean	Lower Bound	2.4415	
			Upper Bound	2.6755	
		5% Trimmed Mean		2.6078	
		Median		2.8000	
		Variance		.875	
		Std. Deviation		.93527	
		Minimum		.00	
		Maximum		4.00	
		Range		4.00	
		Interquartile Range		1.18	
		Skewness		-.849	.155
		Kurtosis		.102	.308

Table 9 indicates the results of a crosstabulation analysis for the Black population relating AP Exams Taken and Gender. For Black males, the expected count of students taking an

AP Exam (114.2) is higher than the actual count (93). For Black female students, the expected count of students taking an AP Exam (133.8) is lower than the actual count (155).

Table 9

Crosstabulation Statistics of Black Students in relation to gender and taking AP Exams

*Gender New *AP Taken New Crosstabulation*

			AP Taken New		
			No	Yes	Total
Gender New	Male	Count	946	93	1039
		Expected Count	924.8	114.2	1039.0
		% within Gender New	91.0%	9.0%	100.0%
	Female	Count	1062	155	1217
		Expected Count	1083.2	133.8	1217.0
		% within Gender New	87.3%	12.7%	100.0%
Total		Count	2008	248	2256
		Expected Count	2008.0	248.0	2256.0
		% within Gender New	89.0%	11.0%	100.0%

Research Question 2c for the present study was written to determine if there is a statistically significant difference in the first-year college GPA of female students between those who have earned Advanced Placement Exam College Credit and those who have no AP Exam College Credit.

The null hypothesis (H_0) is the mean first-year college GPA is not significantly different between female students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2):

$$H_0 : \mu_1 = \mu_2$$

The alternative hypothesis (H_a) is the mean first-year college GPA is lower for female students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2):

$$H_a : \mu_1 < \mu_2$$

To investigate this question, an independent sample *t*-test was initially considered to describe any differences. However, the first-year GPA variable failed the normality test. GPA was standardized to provide equal representation across the values, but it still failed the assumptions of the *t*-test. A non-parametric equivalent of this test was needed. A Mann-Whitney *U* test was conducted to investigate differences in means of these variables. A Mann-Whitney *U* test was performed to evaluate whether first-year GPA differed between female students who had earned AP Exam College Credit and those who did not.

The results indicate that, when considering female students, those who had AP Exam College Credit had significantly higher first-year GPAs (Mdn = 3.56, n = 3672) than the first-year GPAs (Mdn = 2.88, n = 6226) of students who did not have AP Exam College Credit (U = 16696525.5, p = < 0.001; with a small to medium effect size r = 38.352/sq root 9898 = 0.39; Table 10). This allows for the rejection of the null hypothesis (H_0) that there is no difference in first-year GPA for female students between having AP Exam College Credit or not in favor of the alternative hypothesis (H_a).

Table 10

Research Question 2c Analysis using Mann-Whitney U Test

Independent-Samples Mann-Whitney U Test

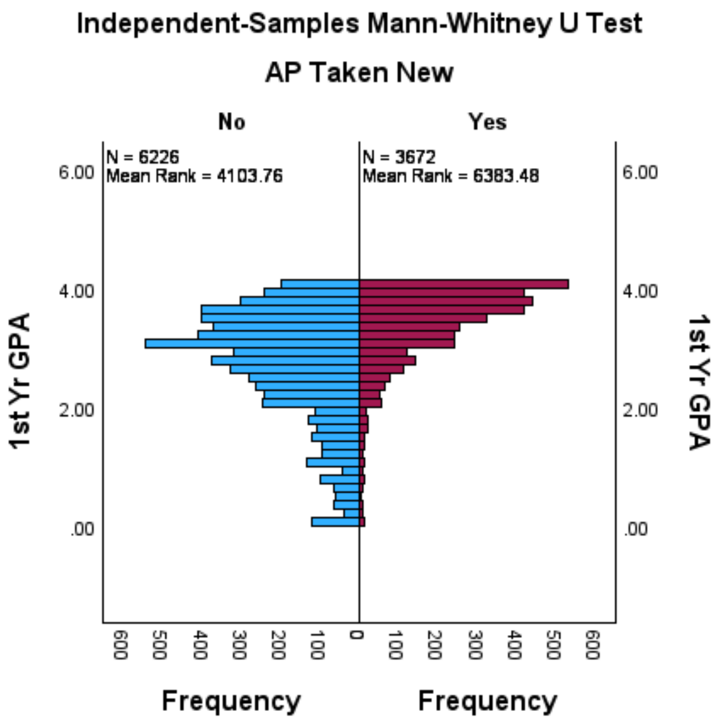
Summary

Total N	9898
Mann-Whitney U	16696525.500
Wilcoxon W	23440153.500
Test Statistic	16696525.500
Standard Error	137297.762
Standardized Test Statistic	38.352
Asymptotic Sig.(2-sided test)	<.001

Figure 9 shows that there is a difference in the ranked sum of the two groups. The mean rank for the GPA for female students who had not taken an AP Exam is 4,104, while the mean rank for the GPA for female students who had taken an AP Exam is 6,383. The figure also shows that female students who had taken an AP Exam had a greater concentration of GPA values closer to 4.00 than those who did not take AP Exams.

Figure 9

Research Question 2c Analysis using Mann-Whitney U Test



Research Question 3 for the present study was designed to determine which predictor variables (gender, race, first-year college GPA, and passing STEM Advanced Placement Exams) are associated with the likelihood of graduating with a STEM degree.

The null hypothesis (H_0) is that there is no difference in the odds ratio between passing STEM Advanced Placement Exams (β_1), first-year college GPA (β_2), gender (β_3), race (β_4), and graduating with a STEM degree:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0.$$

The alternative hypothesis (H_a) is that gender, race, first-year college GPA, and passing STEM Advanced Placement Exams are associated with graduating with a STEM degree:

$$H_a : \beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0.$$

A multiple logistic regression analysis was conducted to estimate the probability of graduating with a STEM degree from four predictor variables. The dependent (response) variable was dichotomous (earning a STEM degree =1, otherwise = 0), and the independent (predictor) variables were passing STEM AP Exams, first-year college GPA, gender, and race. A null model was created where all the beta values were set to 0 and the calculated odds ratio was 1. This is interpreted as these variables having no effect on the model to describe graduating with a STEM degree (no association between the response and predictor variables). Table 11 shows the analysis for the null model.

Table 11

Logistic Regression Null Model Analysis

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 0	Constant	-2.126	.035	3683.877	1	<.001	.119

The full model with all four predictor variables was then fitted. Table 12 shows that this full model allows for 89.2% of cases to fit the model, and Table 13 shows the results of the full model analysis.

Table 12

Logistic Regression Classification Table

Classification Table[a]

	Observed		Predicted: STEM Degree Earned: No	Predicted: STEM Degree Earned: Yes	Percentage Correct
Step 1	STEM Degree Earned	No	7587	59	99.2
		Yes	863	49	5.4
	Overall Percentage				89.2

a. The cut value is .500

Table 13

Logistic Regression Full Model Analysis

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B) Lower	Upper
Step 1[a]	STEM AP Passed	1.104	.089	153.981	1	<.001	3.017	2.534	3.591
	1st Yr GPA	1.372	.096	205.051	1	<.001	3.944	3.269	4.759
	Gender New	-1.042	.076	188.917	1	<.001	.353	.304	.409
	Ethnicity New	-.576	.232	6.149	1	.013	.562	.356	.886
	Constant	-6.458	.334	373.268	1	<.001	.002		

a. Variable(s) entered on step 1: STEM AP Passed, 1st Yr GPA, Gender New, Ethnicity New.

From this model, probabilities and percent change in odds were determined. Equations used to determine these values can be found in the note under Table 14. For the full model, the Nagelkerke R^2 was 0.169, log likelihood was 5061.197, and LR χ^2 was 745.8668. Table 14 presents the logit coefficients, standard errors, odds ratios, probability, and percent change in odds for the full model.

Table 14

Research Question 3 Logistic Regression Complete Analysis

	Null Model		Full Model			
Variables	b (SE(b))	Odds Ratio (EXP(b))	b (SE(b))	Odds Ratio (EXP(b))	Probability*	Percent Change in Odds**
Passing STEM Advanced Placement Exams	0	1	1.104	3.017	0.7511	201.7%
			(0.089)			
First-Year College GPA	0	1	1.372	3.994	0.7998	299.4%
			(0.096)			
Gender	0	1	-1.042	0.353	0.261	-64.7%
			(0.076)			
Race	0	1	-0.576	0.562	0.360	-43.8%
			(0.232)			
Constant	-2.126	0.119	-6.458	0.002	0.002	-99.8%
	(0.035)		(0.334)			
Observations	8558	8558	8558	8558		
Nagelkerke R^2			0.169			
Log Likelihood			5061.197			
Degrees of Freedom			4			
LR χ^2			745.8668			

Note: Standard errors are shown in parentheses. A 95% confidence interval is used with $p < 0.05$.
*Probability = Odds Ratio / (1+ Odds Ratio)
**Percent Change in Odds = (Odds Ratio -1) x 100%

Given the results of the Wald Test, the null hypothesis (H_0) was rejected in favor of the alternative hypothesis (H_a).

For the Passing STEM Advanced Placement Exams predictor, the odds ratio is 3.017 ($p = < 0.001$, 95% CI [2.534, 3.591]). This indicates that, when keeping all other variables constant, passing STEM AP Exams, the odds of graduating with a STEM degree increased by 3.017. This corresponds to being 75.11% more likely to graduate with a STEM degree if a student has passed a STEM AP Exam (201.7% increase in the odds). The crosstabulation of gender and earning STEM degrees (Tables 15 and 16) shows similar trends when comparing expected counts with actual counts of STEM degrees earned by gender.

Table 15

Crosstabulation of Passing STEM AP Exams and Earning STEM Degree

Crosstab

			STEM Degree Earned			Total
			No	Yes	9	
STEM AP Passed	No STEM AP Exams Passed	Count	8026	791	7534	16351
		Expected Count	8120.4	1028.9	7201.7	16351.0
		% within STEM AP Passed	49.1%	4.8%	46.1%	100.0%
	At Least 1 AP STEM Exam Passed	Count	663	310	172	1145
		Expected Count	568.6	72.1	504.3	1145.0
		% within STEM AP Passed	57.9%	27.1%	15.0%	100.0%
Total		Count	8689	1101	7706	17496
		Expected Count	8689.0	1101.0	7706.0	17496.0
		% within STEM AP Passed	49.7%	6.3%	44.0%	100.0%

Table 16

Chi-Square Analysis of Crosstabulation of Passing STEM AP Exams and Earning a STEM Degree

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1091.873[a]	2	<.001
Likelihood Ratio	814.267	2	<.001
Linear-by-Linear Association	362.727	1	<.001
N of Valid Cases	17496		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 72.05.

For the first-year Grade Point Average predictor, the odds ratio is 3.994 (p = < 0.001, 95% CI [3.269, 4.759]). This indicates that, when keeping all other variables constant, every one unit increase in first-year GPA increased the odds of graduating with a STEM degree by 3.994. This corresponds to being 79.98% more likely to graduate with a STEM degree for every one unit increase in first-year GPA (299.4% increase in the odds).

For the gender predictor, the odds ratio is 0.353 (p = < 0.001, 95% CI [0.304, 0.409]). This indicates that, when keeping all other variables constant, being a female decreased the odds of graduating with a STEM degree by 0.353. This corresponds to being 26.1% *less* likely to graduate with a STEM degree if a student is a female (-64.7% decrease in the odds). The crosstabulation of gender and earning STEM degrees (Tables 17 and 18) shows similar trends when comparing expected counts with actual counts of STEM degrees earned by gender.

Table 17

Crosstabulation of Gender and STEM Degree Earned

Crosstab

			STEM Degree Earned			
			No	Yes	9	Total
Gender New	Male	Count	3221	633	3744	7598
		Expected Count	3773.4	478.1	3346.5	7598.0
		% within Gender New	42.4%	8.3%	49.3%	100.0%
	Female	Count	5468	468	3962	9898
		Expected Count	4915.6	622.9	4359.5	9898.0
		% within Gender New	55.2%	4.7%	40.0%	100.0%
Total		Count	8689	1101	7706	17496
		Expected Count	8689.0	1101.0	7706.0	17496.0
		% within Gender New	49.7%	6.3%	44.0%	100.0%

Table 18

Chi-Square Analysis of Crosstabulation of Gender and Earning a STEM Degree

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	315.065[a]	2	<.001
Likelihood Ratio	315.494	2	<.001
Linear-by-Linear Association	166.003	1	<.001
N of Valid Cases	17496		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 478.13.

For the race predictor, the odds ratio is 0.562 (p = < 0.013, 95% CI [0.356, 0.886]). This indicates that, when keeping all other variables constant, being a Black student decreased the odds of graduating with a STEM degree by 0.562. This corresponds to being 43.8% *less* likely to graduate with a STEM degree if a student is Black (-43.8% decrease in the odds).

The crosstabulation of race and earning STEM degrees (Tables 19 and 20) shows similar trends when comparing expected counts with actual counts of STEM degrees earned by race.

Table 19

Crosstabulation of Race and STEM Degree Earned

Crosstab

			STEM Degree Earned			Total
			No	Yes	9	
Ethnicity New	White	Count	6994	891	4893	12778
		Expected Count	6345.9	804.1	5628.0	12778.0
		% within Ethnicity New	54.7%	7.0%	38.3%	100.0%
	Black or African American	Count	652	21	1583	2256
		Expected Count	1120.4	142.0	993.6	2256.0
		% within Ethnicity New	28.9%	0.9%	70.2%	100.0%
	Other	Count	1043	189	1230	2462
		Expected Count	1222.7	154.9	1084.4	2462.0
		% within Ethnicity New	42.4%	7.7%	50.0%	100.0%
Total		Count	8689	1101	7706	17496
		Expected Count	8689.0	1101.0	7706.0	17496.0
		% within Ethnicity New	49.7%	6.3%	44.0%	100.0%

Table 20

Chi-Square Analysis of Crosstabulation of Race and Earning a STEM Degree

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	873.481[a]	4	<.001
Likelihood Ratio	915.287	4	<.001
Linear-by-Linear Association	47.395	1	<.001
N of Valid Cases	17496		

[a]. 0 cells (.0%) have expected count less than 5. The minimum expected count is 141.97.

Summary

This chapter presented the results of statistical analyses performed to investigate each of the three research questions. While maintaining a 95% confidence interval, the null hypotheses for all research questions were rejected in favor of the alternative hypotheses. In the following chapter, interpretation of these results and recommendations based on the interpretations will be presented.

CHAPTER V: DISCUSSION

Introduction

This chapter will focus on the interpretation of the results presented in Chapter 4. These interpretations will be compared to any references from the background literature. Using the results, recommendations and future topics of studies will be identified. Finally, a connection to leadership studies will be derived. The purpose of the current study is to explore any role that AP Exams, race, and gender might have in science achievement. Three research questions were posed and investigated using data from a regional, four-year university.

Research Question 1

The first research question explored the association between having Advanced Placement Exam College Credit (AP) and Time to Graduation. The null hypothesis (H_0) was that there is no association between having AP Exam College Credit and time required to graduate: $\rho = 0$. The alternative hypothesis (H_a) was that there is an association between having AP Exam College Credit and time required to graduate: $\rho \neq 0$. The findings suggested a negative correlation between having Advanced Placement Exam College Credit and Time to Graduation. This correlation was statistically significant (ρ (9788) = -0.205, p = < 0.001). This indicates that as AP Exam College Credit increases, there is a decrease in the number of semesters needed to graduate. This result supported the rejection of the null hypothesis (H_0) in favor of the alternative hypothesis (H_a).

The findings of the current study are supported by Evans (2019) who found that earning college credit while in high school allows students to graduate quicker and increases the likelihood that they will have a double major and take more advanced courses. However, Burns et al. (2019) found that taking AP courses in high school was not linearly related to time to graduation. They argued that AP courses provide a one-time benefit indicating that exposure to one AP course has a statistically significant effect on decreasing time to graduation, but taking additional AP courses does not further reduce time to graduation. I believe this may be the case because students who take multiple AP courses often take them in a variety of content areas. Not all of these AP courses correspond to the college major that the student chooses, so there effectively is a minimum time needed for students to complete their sequence of major courses to graduate. Parker (2022) indicated that having early college credit does not necessarily decrease the time to graduation. Instead, students with AP credit tend to graduate on time (four years); whereas, many of their non-credit peers take slightly longer to graduate. Regardless, the findings from the present study indicate an association between having AP Exam College Credit and Time to Graduation. At the particular institution from which the sample was drawn, the data suggest that having AP credit leads to a faster graduation time compared to not having the credit.

The results of the present study paired with other literature indicates that earning early college credit (such as through AP Exams) allows for a decrease in predicted graduation time. This is likely due to students being able to get many of their general education credits completed in high school, as well as having developed the soft skills (such as study and critical thinking skills) from being exposed to a more rigorous curriculum and higher academic expectations. This in turn accounts for why students with AP credits are more likely to graduate on time with double majors (Evans, 2019).

Research Question 2

The second research question explored if there was a difference in first-year GPA between students who took AP Exams and those who did not take any AP Exams. This question was divided into three sub-questions based on populations of interest.

Research Question 2a sought to determine if there was a difference in the first-year college GPA of all students between those who have earned AP Exam College Credit and those with no AP Exam College Credit. The findings suggested that, when considering all students, those who did have AP Exam College Credit had significantly higher first-year GPAs than those students who did not have AP Exam College Credit (U = 49685737.5, p = < 0.001).

Research Question 2b sought to determine if there was a difference in the first-year college GPA of Black students between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit. The findings suggested that, when considering Black students, those who did have AP Exam College Credit had significantly higher first-year GPAs than those students who did not have AP Exam College Credit (U = 346781.0, p = < 0.001).

Research Question 2c sought to determine if there was a difference in the first-year college GPA of female students between those who have earned Advanced Placement Exam College Credit and those with no AP Exam College Credit. The null hypothesis (H_0) was that the mean first-year college GPA is not significantly different between female students who do not have AP Exam College Credit (μ_1) and those who do have AP Exam College Credit (μ_2): $\mu_1 = \mu_2$. The alternative hypothesis (H_a) was that the mean first-year college GPA is lower for female students who do not have AP Exam College Credit (μ_1) than those who do have AP Exam College Credit (μ_2): $\mu_1 < \mu_2$.

The findings suggested that, when considering female students, those who did have AP Exam College Credit had significantly higher first-year GPAs than those students who did not have AP Exam College Credit (U = 16696525.5, p = < 0.001). This allows for the rejection of the null hypothesis (H_0) that there was no difference in first-year GPA for female students between having AP Exam College Credit or not in favor of the alternative hypothesis (H_a).

The literature supports the findings of a positive relationship between earning AP Exam College Credit and first-year GPAs (Scott et al., 2010). Wyatt et al. (2018) showed that students who took AP Exams earned statistically significant higher scores in later college classes compared to those who did not have AP credit for introductory courses. Scott et al. (2010) described that within a similar grouping of students (such as all White or all female), students earning AP Exam College Credit earned higher first semester GPAs in college. These studies showed the positive impact of AP Exam College Credit on college GPAs, but Black students are underrepresented in AP Course enrollment (Whiting & Ford, 2009). Is this due to an innate difference between races or something that may be more systemic? Fryer Jr. and Levitt (2004) indicated that the academic performance gap between White students and Black students may not be naturally derived. They indicated that both groups of students start kindergarten with similar academic performance scores and indicators. Within the first two years of schooling, though, the achievement gap begins to widen. Black students performed at statistically significant levels below White students by the end of the first two school years. The authors suggested this might point to a difference in the quality of schooling. A later study by these authors showed that by the end of third grade, Black students have lost substantial ground compared to other groups—approximately 0.10 standard deviations per school year (Fryer Jr. & Levitt, 2006). They found that no observable characteristics (including systematic differences in school quality) can explain the performance gap and that something bigger must be at play.

In all three subquestions for Research Question 2, the findings suggested that having AP Exam College Credit correlated with a higher first-year GPA regardless of race or gender. From my experience as a high school educator, this seems reasonable, as Advanced Placement courses are typically chosen by students who already have strong high school GPAs and/or those students who have a desire or reason to take advanced coursework in high school. By taking AP courses, these students must work harder with rigorous content and develop their academic soft skills. These skills carryover into their college courses allowing them to be more successful in their first year (Klopfenstein & Thomas, 2009). This is important when considering that low early college (first semester) GPA is a statistically significant factor in why underrepresented groups do not graduate (Gershenfeld et al., 2016). In the present study, 10.0% of the Black students took an AP Exam in high school, while 37.1% of White students took an AP Exam. Specifically for STEM AP courses, 0.3% of Blacks passed at least one STEM AP Exam, while 7.6% of White students passed at least one STEM AP Exam. For White students, the mean first-year GPA with not having taken an AP Exam is 2.70 and the mean first-year GPA with having taken an AP Exam was 3.32. For Black students, the mean first-year GPA with not having taken an AP Exam is 1.91 and the mean first-year GPA with having taken an AP Exam was 2.56. With these differences evident, educational institutions should support students (especially underrepresented groups) during their first year of college to lead them on a path of greater collegiate success. From a high school educator or student perspective, it appears that taking high school Advanced Placement courses sets up students for success during the first year of college.

Research Question 3

The final research question sought to determine if any of the predictor variables (passing STEM Advanced Placement Exams, first-year GPA, gender, and race) were associated with the likelihood of graduating with a STEM degree. The null hypothesis (H_0) was that there is no difference in the odds ratio of passing STEM Advanced Placement Exams (β_1), first-year college

GPA (β_2), gender (β_3) and race (β_4) and earning a STEM degree: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$.

The findings suggested that all four predictor variables do have a significant effect on the odds ratio of earning a STEM degree. While keeping all other variables constant, passing STEM AP Exams increased the odds ratio of earning a STEM degree. While keeping all other variables constant, higher first-year GPAs increased the odds ratio of earning a STEM degree. While keeping all other variables constant, being Black decreased the odds ratio of earning a STEM degree. While keeping all other variables constant, being a female decreased the odds ratio of earning a STEM degree.

The results for this research question appeared to be in line with other studies that describe various factors that might enhance STEM degree attainment. Jewett and Chen (2022) found that taking AP STEM courses have a significant impact on predicting STEM major selection by students. Smith et al. (2018) showed that AP STEM examinees had a 7% higher first-year STEM GPA and a 13% higher probability of earning a STEM degree than students who took no STEM AP courses. These findings seemed to hold true for underrepresented students when it comes to race as well as gender.

First-year GPA's association with earning STEM degrees is supported by Thompson (2021). Thompson indicated that first-year STEM grades account for the biggest difference in students who ultimately complete a STEM degree program compared to those that do not. Thompson noted the importance of feeling successful early in STEM programs as an important factor that drives program completion. Young et al. (2016) showed that regularly graded homework appears to be correlated with higher final grades in college courses as well as leads to students graduating on time. This may be an essential intervention that can help students earn higher first-year GPAs which in turn could increase the chances of graduating with a STEM degree. Even if time constraints prevent educators from grading every homework assignment, ungraded descriptive feedback can also lead to positive benefits of homework (Schimmer, 2016). Nix and Perez-Felkner (2019) indicated that in high school mathematics courses, the performance gap is wider between males and females than it is between White and non-White students. Their results indicated that performance levels varied more strongly with regard to gender than race. Weber (2012) showed that female students often perceive that they are locked out of STEM courses and careers. Interestingly, Ma and Liu (2015) showed that there is consistent evidence that Black students are well represented in STEM major choices (indicating underrepresented groups interest in STEM). However, they are well under-represented in STEM degree completion. In the present study, a low number of Black students are completing STEM Degrees. Table 19 (Chapter 4) indicated that within the time period of slightly over a decade, just 21 Black students earned STEM Degrees, which was much lower than the expected count of 142. Table 17 also shows that the number of females earning STEM Degrees was lower than the expected number.

It is difficult to find literature that contradicts the findings of the current study. Passing STEM AP Exams and first-year GPA seem to have a positive effect on earning STEM degrees (Jewett & Chen, 2022; Smith et al., 2018; Thompson, 2021), while being Black or female tends to have a negative association earning STEM degrees and occupations across the literature (Ma & Liu, 2015; Botella et al., 2019). The literature and current study suggest systemic factors are influencing these realities.

Critical Race Theory seeks to explain potential reasons why societal, historical, and systemic paradigms may lead to the performance of Black students. CRT argues that standard assessments and even grading practices may be unintentionally designed in a way that benefits the experiences of White students over those of other students (Cobb & Russell, 2015). Further, curricula are designed without understanding that life experiences are not shared equally by all students (Yosso, 2002). Leaving out a consideration of race has negative impacts on the success of Black students as outlined in Chapter 2. The literature review included studies that described the reasoning why women are often underrepresented in STEM fields. I believe that a significant reason behind both groups' lower success in degree attainment is in part due to a lack of support and engagement at a young age. Through the formative school years, science courses point out the successes of scientists who fit the mindset of a White male. Students are not given opportunities to see or hear about the successes of underrepresented or female scientists unless there is a reason to (such as Women's History Month or Black History Month). Historically, the role of women and racially underrepresented groups in curricula has not been naturally embedded. This paired with gender roles and stereotypes leads to the exclusion of Black and female students from the sciences starting at an early age. While homework has shown promise in helping develop academic skills as well as soft skills, it must be equitable. Homework is a complex interplay of various aspects such as parental support and household conditions. We have to be careful that the homework provided is meaningful and that students can complete it; otherwise, homework may add to the problem of inequitable educational outcomes (McCrory et al., 2022). Intentional planning of curriculum, consistent incorporation of underrepresented groups in STEM, maintaining rigor, incorporating effective and equitable homework policies, and supportive mentorship may help to change the perspective that STEM is not for these underrepresented groups.

Leadership Model

The results and recommendations of the current study allow for practical interventions in school buildings that can help shape the culture of equity in schools. My primary leadership style would involve understanding the balance between all five key areas of leadership: leaders, followers, goals, environmental context, and cultural context (McManus, 2015). Within the context of leadership models, I follow a servant leader role as well as believing in the philosophy of a transformational leader. My background as an educator has allowed me to understand the role of a servant leader and the positive impact that it can have on followers and goal attainment. A servant leader is one who focuses on the followership first (Coetzer et al., 2017). They focus on the growth, happiness, and safety of the stakeholders before considering themselves. They believe in sharing the "power" and think about developing their followership to meet their greatest potential. A transformational leadership style is one in which a leader focuses on helping develop a vision for an organization and leading the followership towards that vision (Korejan & Shahbazi, 2016). A transformational leader works to inspire change within an organization to build a strong culture where stakeholders feel part of the community and the change. This goes beyond simply offering incentives and rewards (transactional leadership style). A transformational leader builds a common value system and a shared purpose. This aligns with my pragmatic, transformative ontological perspective, as I seek to learn more about the nature of education but want to make real changes based on areas of growth that I discover.

When examining a school structure, a transformational leader helps to develop a positive school culture for staff and students (McCarley et al., 2016). I believe a foundational aspect of building a strong school culture comes from believing that all students can succeed. Further, students must know that the adults in the building want them to succeed and are present for students in the learning process. This is why I believe in the impact of data-driven decisions. The results of the current study support the idea that female students and Black students are more likely to be left behind when considering STEM education. The results of the current study show that being female or Black led to a decrease in the odds ratio of graduating with a STEM degree. Additionally, the study supports taking Advanced Placement Exams and first-year college GPA tend to increase the odds ratio of increasing with a STEM degree. A transformational leader would use these results and implement specific interventions to help underrepresented groups become more successful in STEM classes, as well as encourage them to take more advanced STEM coursework. A unified school vision of increasing representation in advanced high school science classes may lead to positive results. Focusing on interventions that help students in these groups in regular science classes is also essential. These interventions can be extra tutoring during the school day or offering after-school, flexible tutoring opportunities. Because research has shown that intentional homework seems to have an influence on first year college GPA (Young et al., 2016), I would look at homework and grading policies at schools who have shown academic success with underrepresented groups – especially in STEM areas. This information paired with the needs of the students in my building would help to develop a school-wide vision for homework and its importance in the long-term success of students. A transformational leader would also provide opportunities where speakers may come into the school or students take a field trip to see scientists from underrepresented groups in action. Allowing underrepresented students to see "someone like them" in a successful STEM career may help the students feel that STEM is more attainable (Funk, 2022). This would align with the ultimate goal of a transformational leader: transform the mindset of all stakeholders. The leader would help all students, especially those in underrepresented groups, feel like they could be successful and that they can pursue knowledge in any area that they desire and are willing to work towards.

Recommendations

The findings suggest that students from underrepresented groups (Blacks and females) tend to have lower science achievement. It is important to first look at the conceptual framework for recommendations. The goal of the American education system is to provide opportunities to learn for all students as evidenced by the construction of accountability systems (Elliott, 2015). The findings indicate that students in certain groups are not succeeding in STEM areas as well as other student groups. Therefore, the goal should include equitable practices that allow all students to grow and have opportunities for lifelong success in STEM areas. School leaders should focus on equity and inclusion of students; this should be more than words or "checkboxes" on accountability forms. Leadership in schools, universities, and other educational institutions should actively work to recruit and support Black and female students. Curricula should be aware of the positive impact that integrating underrepresented group successes into the instruction can have on all students. We should be cognizant of educational poverty that may exist within school buildings and the community. This poverty can stem from access to physical resources, as well as from access to support systems that encourage educational success. Finally, understanding that there may be systemic barriers that students face (as described by Critical Race Theory) may help educational systems evolve to consider ways to help students move past these barriers. There should be an interest convergence where the schoolwide shared vision builds student confidence in learning STEM and helps students visualize themselves in STEM careers.

As an educator and pragmatist, I believe the current exploration also lends itself to providing practical recommendations that can be employed in educational institutions to help underrepresented students (Blacks and females) in STEM courses be more successful and ultimately pursue STEM careers. First, schools should focus on providing opportunities for early exposure and engagement in STEM concepts such as STEM clubs, afterschool programs, or summer programs. Leaders should seek out and genuinely employ culturally relevant curriculum that incorporates case studies, scenarios, and people of importance in the STEM field. This allows students to see themselves as STEM practitioners and can see how people "like themselves" have been successful in STEM fields. Leaders should also provide supportive learning environments with mentorship opportunities that are embedded. This model helps students collaborate and learn from wrong answers/bad assessments. Leaders should help students avoid self-fulfilling prophecies when they are not successful. Mentorship should play the role of encouraging students to take advanced courses in STEM (such as AP courses), as well as helping students develop a pathway to STEM careers. Teachers and educational leaders should not simply avoid stereotype threats; they should actively learn about them and address these threats in their classrooms. To do this, educators should encourage a growth mindset and emphasize academic resilience. Students should be reminded that learning does not happen overnight. It is a long journey of successes and failures.

Educators should also understand the importance that homework may have in their instructional model and success in their coursework (Cooper et al., 2006; Young et al., 2016). Bennett et al. (2013) showed that students who took a common engineering introductory course earned final grades that correlated with completion of homework. The authors found that students who completed less than 80% of the homework had a course pass rate of 33.3%. Homework can be used to build soft skills and reinforce academic content for students (Pllana, 2022). Further, homework can also lead to fostering growth of independent problem solving (Schimmer, 2016). Though, it is also important to understand that not all students are able to go home and concentrate on completing assignments. If we believe in the power of assignments and want to provide equitable instruction, educators should consider individual student's situations and determine an equitable way to maximize the benefit of homework.

The present study has shown the impact of Advanced Placement exams in first-year college GPAs and graduating with STEM degrees. High school educators and counselors should try to actively recruit more Black and female students into these courses. They may be tougher, and students may feel as if they are not capable, but a supportive learning environment and mentorship program (mentioned above) can help to resolve this mindset. Finally, the most important recommendation that I believe can be given is to emphasize data-driven decision making. Schools, universities, and leaders should constantly be examining data regarding their students' performance. They should consider whole-group data, as well as data that are disaggregated by race and gender. Leaders should always look for disparities and apply interventions to reduce these disparities in a measurable manner.

Future Studies

The current study is an exploration of factors as they relate to science achievement. One of the purposes of an exploratory study is to identify new ideas or areas of research. The findings of the present study raise several new potential research topics for further studies. First, I would like to explore the Black group further to investigate complex differences that may exist within the group itself. Investigating factors such as socioeconomic status, gender, levels of familial and educational support, familial degree attainment, self-confidence in STEM fields, and school attendance rate are some of the predictor variables that may help elucidate criteria for STEM success in students. Additionally, qualitative data on perceptions regarding school and STEM careers may also help delineate the difference between those who are successful in STEM degree paths and those who are not. I would also like to investigate the impact that the type of high school attended has on STEM degree attainment. Does attending a public, private, religious, charter, homeschool, or online school make a difference? I also believe it is important to look beyond the delimitations set in the current exploration. Future studies could utilize a larger university setting, such as a four-year state university or even compare race/gender data between top Ivy League schools versus state schools. An expansion into reviewing success criteria for any degree attainment (not just STEM) may also provide a better picture of the underrepresented groups with respect to college degree attainment. In the current study, I was not able to obtain data on the total number of Advanced Placement exams taken by students, nor was I able to obtain a graduating GPA. I would like to see if a higher number of AP Exams taken would impact time to graduate, graduating GPA, or STEM degree attainment.

In the literature review, the case of homework was described as a bellwether for the state of education. Literature showed mixed results on the impact of homework and STEM achievement. Further studies could provide more modern evidence on possible associations between homework and several success outcomes including student development of soft skills and degree attainment. I would also like to see if the role of homework throughout the schooling process has an impact on underrepresented groups at various stages of the process. I would like to see if homework has an impact on success at the elementary, middle, high, and collegiate levels. The impact of homework goes beyond test performance; it also fosters skills that help with content reinforcement and test preparation (Pllana, 2022). Does homework provide a form of practice and support to underrepresented students, or does it represent a hindrance to their perception and confidence in STEM success? Finally, I would like to investigate further into how components described in Critical Race Theory may impact the mindset, attitudes, and success of underrepresented groups at various levels of schooling.

Summary

The final chapter discusses the importance and implications of the current exploration. The purpose of this study was to explore any role that AP Exams, race and gender might have in science achievement. All three of these variables appear to have an impact on science achievement. From these findings, several recommendations and possible topics for future studies are provided. Practical applications of the findings are also suggested as a way to encourage higher STEM achievement in Black and female students. Finally, implications of the current study are discussed in the scope of a transformational leadership model. Hopefully, the findings presented in this current study will help spark further interest in working towards greater educational equity in order to see a more representational STEM workforce in the future.

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APPENDIX A: IRB Approval

WESTERN KENTUCKY UNIVERSITY

Institutional Review Board
Continuing Review Report

INSTITUTIONAL REVIEW BOARD WKU APPROVED

Request, please complete a new application.
Otherwise; DO NOT include the complete application in describing modifications and requests for additional time to collect data.

Name of Project: Racial and Gender STEM Degree Attainment (Reference # 22-311)
Name of Researcher: Amar Patel
Department: EdD Program

How many total subjects have participated in the study since its inception? # 0 (data from WKU only)

How many subjects have participated in the project since the last review? # 0 (data from WKU only)

Is your data collection with human subjects complete? ☐ **Yes** ☐ **No** **X N/A**

1. Has there been any change in the level of risks to human subjects? (If "Yes", please explain changes on a separate page). ☐ Yes ☒ No

2. Have informed consent procedures changed so as to put subjects above minimal risk? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

3. Have any subjects withdrawn from the research due to adverse events or any unanticipated risks/problems? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

4. Have there been any changes to the source(s) of subjects and the Selection criteria? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

5. Have there been any changes to your research design that were not specified in your application, including the frequency, duration and location of each procedure. (If "Yes", please describe on a separate page). ☒ Yes ☐ No

6. Has there been any change to the way in which confidentiality of the Data is maintained? (If "Yes", please describe on a separate page). ☐ Yes ☒ No

7. Is there desire to extend the time line of the project? ☒ Yes ☐ No
   On what date do you anticipate data collection with human subjects to be completed? There is no data collection directly from human subjects. Data is obtained from WKU Institutional Research only – no identifying data. I would like to extend my project until May 2025.

WESTERN KENTUCKY UNIVERSITY

Institutional Review Board
Continuing Review Report

New Research Questions:

The purpose of this study is to explore the potential role of race and gender in science achievement. (Race, gender, and science achievement are defined in the 'Definitions' section below.) In order to build a case for the role of race and gender in science achievement, it is important to consider each factor separately. This is the purpose of the first three research questions. The final research question explores how a variety of factors relate to the ultimate goal of STEM degree attainment at Western Kentucky University.

- Research Question 1
  - Is there an association between having Advanced Placement Exam College Credit and Graduation Time?
- Research Question 2
  - Is there a statistically significant difference in the College Graduating GPA of all students between those who have earned Advanced Placement Exam College Credit and those who have no AP College Credit?
  - Is there a statistically significant difference in the College Graduating GPA of African American students between those who have earned Advanced Placement Exam College Credit and those who have no AP College Credit?
  - Is there a statistically significant difference in the College Graduating GPA of female students between those who have earned Advanced Placement Exam College Credit and those who have no AP College Credit?
- Research Question 3
  - Is there an association between the number of Advanced Placement Exams passed and Graduation Time?
- Research Question 4
  - Do gender, race, first-year college GPA and passing STEM Advanced Placement Exams have an influence on graduating college with a STEM degree?

Data Collected from WKU Institutional Research is listed below.
No student identifying information (name, WKU ID, Social Security, Birth Date, Address, Phone Number, etc.) was requested.

- Cohort requested: start Fall 2012 through Fall 2017; first-year, full-year, full-time only; graduate by Spring 2023
- Gender
- Race
- First-year College GPA
- College Graduating GPA
- Advanced Placement Exam taken (Yes/No)
- Total Number of AP Exams Passed (Score of 3, 4, or 5)
- AP Biology score
- AP Chemistry score
- Any AP Math score (AP Calculus AB, AP Calculus BC, AP Statistics)
- Any AP Physics score (AP Physics 1, AP Physics 2, AP Physics C: Mechanics, AP Physics C: Electricity and Magnetism)
- Graduation Term (this was used to determined semesters needed to graduate)
- In what Major was a degree earned
- STEM Degree earned: Biology, Chemistry, Engineering, Geology, Mathematics, Physics (Yes/No)

APPENDIX B: Data Requested from Institutional Research

- Cohort requested: start Fall 2012 through Fall 2017; first-year, full-year, full-time only; graduate by Spring 2023
- Gender
- Race
- First-year College GPA
- College Graduating GPA
- Advanced Placement Exam taken (Yes/No)
- Total Number of AP Exams Passed (Score of 3, 4, or 5)
- AP Biology score
- AP Chemistry score
- AP Calculus score (AP Calculus AB or AP Calculus BC)
- AP Statistics score
- Any AP Physics score (AP Physics 1, AP Physics 2, AP Physics C: Mechanics, AP Physics C: Electricity and Magnetism)
- Enrollment Term (this was used to determined semesters needed to graduate)
- Graduation Term (this was used to determined semesters needed to graduate)
- In what Major was a degree earned
- STEM Degree earned: Biology, Chemistry, Engineering, Geology, Mathematics, Physics (Yes/No)

APPENDIX C: Codebook of Variables of Interest

Description	Variable	Label	Values	Measure
Reported Gender of Individual	Sex_New	Gender New	0 = Male 1 = Female 99 = Other Responses	Nominal
Reported Race of Individual	Ethnicity_New	Ethnicity New	0 = White 1 = Black or Black 99 = Other Responses	Nominal
First Year Grade Point Average	COLL_GPA	1st Yr GPA	[0, 4.00]	Scale
Number of semesters taken to graduate	Semesters_to_ Graduate	Semesters to Graduation	[1, 32]	Scale
Taking any AP Exams regardless of content area and score	AP_Taken_New	AP Taken New	0 = No 1 = Yes	Nominal
Passing at least one STEM AP Exam (score of 3-5)	STEM_AP_ Passed	STEM AP Passed	0 = No 1 = Yes	Nominal
Earning at least one STEM BA/BS degree	STEM_Degree_ Earned_New	STEM Degree Earned	0 = No 1 = Yes 9 = No degree earned (did not graduate)	Nominal