IDENTIFYING BARRIERS TO STEM IN UNDERREPRESENTED GROUPS

A Thesis
Presented to
The Academic Faculty

by

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In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science in the
School of Physics

Georgia Institute of Technology
May 2024

IDENTIFYING BARRIERS TO STEM IN UNDERREPRESENTED GROUPS

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ACKNOWLEDGEMENTS

I am grateful to my advisor, Dr. Emily Alicea-Muñoz, for entrusting me with the autonomy to pursue this project and for providing the opportunity to present my findings to the American Association of Physics Teachers. Special thanks to Dr. Mike Schatz for his support and for involving me in the Physics 1111 pilot program, which has the potential to offer further insights into diversifying our field in the future. I extend my appreciation to the entire PER team for their unwavering support throughout this endeavor. Last but not least, I am thankful to Dr. Edwin Greco for introducing me to physics education research and for challenging me to reimagine conventional learning experiences.

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Figure 1 [16]: This graph illustrates a five-year average of the percent of physics bachelor's and doctoral degrees awarded to people of various races and ethnicities. Degrees awarded to temporary residents are not included in the calculations. Data on the college age population are collected from the U.S. Census. US Indigenous includes American Indians, Alaska Natives, Native Hawaiians, and other Pacific Islanders.

SUMMARY

The persistent underrepresentation of minority groups, women, and individuals from disadvantaged socio-economic backgrounds in STEM fields, particularly physics, remains a significant challenge. This thesis aims to delve into the multifaceted barriers that perpetuate this issue, ranging from societal stereotypes and environmental factors to the pervasive imposter syndrome.

Through the lens of Critical Race Theory (CRT), which posits that the overlap of race and property rights can illuminate social biases, this research seeks to identify and analyze the systemic inequities within educational institutions that hinder the participation of underrepresented groups in physics and other STEM disciplines. Additionally, other contributing factors, such as the lack of qualified physics educators in high schools, further dissuade individuals from pursuing degrees in this field.

Utilizing a combination of qualitative methods including literature reviews and interviews with undergraduate physics majors at Georgia Tech and K-12 educators from Gwinnett County, this study aims to uncover the root causes of the lack of diversity in STEM fields. The narratives provided by the participants offer valuable insights into the challenges and obstacles faced by individuals aspiring to enter these fields and successes that could aid in viable solutions.

By shedding light on these barriers and their systemic origins, this thesis hopes to contribute to the ongoing discourse on promoting diversity and equity in STEM education. It underscores the importance of addressing these issues at various levels, from policy-making to institutional practices, to foster a more inclusive and equitable environment for all individuals interested in pursuing careers in STEM.

CHAPTER I

INTRODUCTION

The field of physics has produced numerous scientific and technological advances yet faces a significant lack of diversity regarding representation across various demographic groups. Researchers have conducted studies to evaluate and understand the causes behind underrepresentation of minority groups in earning physics degrees and the negative effects they could present to the health of the physics field and the U.S. scientific enterprise in the future [13]. This lack of diversity is problematic because it limits the pool of talented scientists that could potentially advance the field further and although the past 20 years has seen an increase in physics degrees obtained, underrepresented groups (URGs) such as African Americans have declined since 1994 and have remained stagnant [4][22]. To drive change, the American Institute of Physics assembled TEAM-UP, a national task force, to increase representation of African Americans in physics and astronomy [4].

The causes behind the lack of diversity in physics are complex and various. Systemic barriers like limited access to quality education and the lack of inclusive environments hinder individuals of URGs from pursuing a career in physics. Analyzing school inequalities through the lens of the CRT, which proposes that race remains a significant factor when evaluating discrimination in the U.S. and that society is based on property rights and not human rights. The original purpose of multicultural education was to foster change and promote educational equity among various racial, ethnic, and social-class demographics. However, its implementation has often reduced it to

superficial examples and cultural artifacts, although still presenting a major concern of curriculum inclusion within higher education institutions [14]. While a teacher from a study done by Kelly, believed that physics participation at his school suffered from not having the resources to perform "exciting demonstrations and design interesting labs" that were factors in attracting students to physics [13]. Physicists in the 1950s and 1960s felt the problem stemmed from physics being perceived as a general science at the elementary and middle levels combined with only a small percentage of teachers having earned physics degrees [12]. This meant that students may only be introduced to physics as a discipline at high school and college levels. While this might contribute to the overarching problem, the absence of diverse role models and mentors further compounds the challenges faced by URGs aspiring to be physicists, but the presence of such role models and mentors has proved to help all students [17]. Moreover, stereotype threats and biases have been shown to discourage progression in diversity, causing students to underperform even when they care about the subject [17][21]. The concern, if left unchanged, is the negation of talented individuals' contributions to scientific advancements and societal progress. The lack of diverse voices in research and decision-making leads to narrow perspectives and limited insights into complex problems that can lead to biased results.

My research seeks to validate barriers found in previous studies and potentially uncover new ones, then propose potential solutions that cultivate a more inclusive and equitable physics community. I will collect qualitative data through semi-structured interviews with current undergraduate and graduate physics majors as well as educators in elementary, middle, and high schools in Gwinnett County. I aim to identify which barriers still exist from previous studies, whether any have been dissolved, or if new ones have emerged. I will use targeted research subjects with diverse backgrounds to guarantee a good match with the expected overall population to avoid data that

generalizes behavior and falls short of producing helpful solutions found to create outliers in previous PER studies [11]. I plan to conduct a comprehensive analysis of barriers and potential solutions, that I hope will achieve a physics landscape which accepts the contributions and talents of individuals from all backgrounds, thus strengthening the field and its impact on society.

CHAPTER II

LITERATURE REVIEW

Lack of diversity has been and still is a problem that exists in science today [10]. Diversity boosts creativity and impartiality while growing an environment for various ways of thinking that strengthens science [6][17]. Researchers have conducted studies over the years to evaluate and understand the causes of underrepresentation of minority groups in earning physics degrees and the negative effects it could present to the health of the physics field and the U.S. scientific enterprise in the future [13]. Some studies examined these barriers and aimed to provide potential solutions such as learning assistants, bridge programs, federal programs, and approaches to inclusion, such as the TEAM-UP task force [2][4][8][18]. In the past 20 years, there has been a significant increase in the number of physicists. However, that number gets substantially smaller when we look at underrepresented groups (URG) such as African Americans which has stalled at about 4%, showing a decline since 1994, in comparison to Hispanics that rose to 8.8% and women growing to 21% in 2020 [4][22].

Researchers have used both quantitative and qualitative methods to gather crucial information to reveal barriers that keep URG from pursuing physics degrees. In one study that looked at the underrepresentation of women in physics, neoliberal and social justice rationales were the motivations behind the push for solutions to increasing underrepresentation. Neoliberal rationales favor policies that promote a robust physical science workforce that boost and support the national economy, health care, defense and domestic security. But neoliberal motivations prioritize economic achievement over directly challenging established physics' culture and norms. While

social justice rationalizes that an increase of women in science will enhance science quality through broader inquiry scope and provide diversified data interpretation, it is noted that social justice rationale is rarely implemented over neoliberal principle when trying to strengthen the number of women in physics [6].

When considering the factors that would stop someone from pursuing a physics degree, a primary concern of physicists in the 1950s and 1960s was high school physics courses, since they served as the first introduction to the material and opportunity for students to experience the discipline. Their worries stemmed from the perception that physics was considered a general science and not looked at as a separate specialty and the fact that only a small group of teachers had earned physics degrees. NCES reported that 42% of physics teachers in the U.S. did not earn physics degrees, while 57% of them taught subjects other than physics [13]. These concerns lead to symposia in efforts to develop science instruction in elementary schools. Although professional physicists did not have sole authority to develop K-12 curricula, they worked collaboratively with the teachers who determined what material was taught in their classrooms [12]. In Kelly's study, one of the variables identified that led to students choosing physics was the influence of academic experiences in elementary and middle school science. High school teacher quality was linked to promotion of STEM interest in women and underrepresented minorities. Evaluating these positive connections that led to students pursuing physics degrees validates and warrants a universal change to teaching methods that ensures a standard of quality across all demographics. In Israel, researchers evaluated transitional methods from traditional methods to project-based learning (PBL). PBL was founded on the idea of focusing on facilitating self-directed, intentional inquiry of real-world issues while enabling social interaction in the learning space. A few of the outcomes

showed that students retained knowledge over a longer period, experienced a variety of learning tasks, and mastered communication skills through problem solving [5].

Studies have revealed an oblivious and perpetual barrier known as stereotype threat that played a major role in discouraging progression in diversity, causing students in underrepresented groups to underperform even when they cared about the subject [17][21]. The realization of this barrier led to the construction of implementing tasks that better support all students, but researchers must address whether these reforms are for all students. Positive examples stemmed from careful examination of curricula and learning environments of course material [21]. By shifting the attitudes and mindsets of students from negative to a positive one means not completely communicating to students that scientists come from one demographic group, while most contributions have come from white male Europeans, it is imperative that physics be presented as accurately as possible. For example, it has been found that Newton's first law can be linked to predecessor Ibn Sina, a Persian scholar [17]. Presenting a truer model of physicists of past and present, has proven to diminish stereotype threats as well as implicit bias [17].

Other solutions to barriers look at learning assistants that were used by instructors and their associations with decreases in drop, fail, withdrawal (DFW) of courses towards a STEM degree. Dusen et al. studied and tested the effectiveness of learning assistants from the framework of the quantitative CRT perspective. This resulted in a progression of equity of outcomes but revealed some inequities that still existed in learning assisted courses, leading them to conclude that adding learning assistance may not be adequate to address classism in student outcomes. The declines in DFW rates related to learning assistants were not equal across all marginalized groups [2]. Bridge programs, a material resource provided to marginalized students, promotes positive acknowledgement that allow these students to be viewed as credible physics community members,

but these programs only reach a small fraction of these students [8]. The American Institute of Physics convened the national task force, TEAM-UP, to bolster African American representation in earning bachelor's degrees in physics and astronomy. Its findings revealed barriers of non-supportive departmental environments; in 2008, only 15% of US physics departments had African American faculty, and financial hardships were significant barrier factors for these students. The task force's findings also suggest a cultural shift in attitudes and how African American students perceived themselves as well as outside perceptions [3][4]. Scott et al. argued that despite structural hindrances, many girls of color showed interest in the technology field but did not possess pertinent cultural opportunities to pursue these disciplines.

Lastly, a critical key perceptive, a look at education through the framework of the CRT. By examining ingrained racism within institutions and everyday practices to challenge structures with the intent of achieving racial equity and advancing social justice. The role of counternarrative, color blindness and interest convergence, property of white people. Counternarratives play a crucial role in challenging the narratives of dominant groups, which often depict their superior position as inherently natural [1][20][15]. Carter G. Woodson observed that a school was structuring inequality and demotivated African-American students. In 1933, he wrote, "The same educational process which inspires and stimulates the oppressor…depresses and crushes …the spark of genius in the Negro by making him feel that his race does not amount to much…" in his publication, *The Miseducation of the Negro* [14].

For the current research, I will gather data to identify if there are differences in the barriers encountered by various underrepresented groups, by interviewing a diverse pool of undergraduate physics majors and K-12 educators. I will interview educators that teach both in low-income and wealthier communities, to evaluate and compare how the K-12 science curriculum is designed

based on financial factors. By studying these findings, the project will attempt to model an equity system that implements physics knowledge at earlier stages in K-12 education [12] across all schools within a district. The project will evaluate what has and has not worked in the past. I will try to determine how problem-solving methods and strategies can be successfully implemented by K-12 teachers to strengthen problem-solving skills and attitudes toward physics to increase the number of URGs and to help cultivate their own physics identity [7][9]. In doing so, my project aims to improve existing programs and change societal mindsets among different groups to promote inclusion and success through inspiring and equipping African Americans, women, and Hispanics in the field of physics.

CHAPTER III

METHODS AND PROCEDURES

Data Collection

Some initial expectations of barriers that prevent underrepresented groups from pursuing a physics major are financial, limited access to courses and material, and internalized oppression. Through the collection of new data, we aim to show whether it supports or disproves these initial expectations in areas of underrepresentation (i.e., African Americans) in the field of physics.

The method chosen for this research was semi-structured interviews, we obtained approval from Georgia Tech's Institutional Review Board (IRB; Protocol #H23100) before beginning the data collection. I chose to approach subjects face-to-face on and off-campus in lieu of survey method, I engaged in conversations about my research and how their input could be instrumental in increasing diversity in physics. It was through these interactions that I was able to obtain interviews with physics students at Georgia Tech, as well as educators in the Gwinnett County Public School District. The goal is to get 50 interviews, to ensure a diverse range of data from subjects that identify as African Americans, Caucasians, Hispanics, Asians, males, and females to minimize the data being bias.

I scheduled independent face-to-face interviews with individuals and asked some scripted questions (provided below) as well as some follow-up questions based on their answers to my questions. Each subject was given a consent form and made aware of their rights for participation in the study. The interviews lasted approximately 20-40 mins or longer depending on the subject

and how comfortable they felt sharing information. Some interviews were conducted in-person while the rest were conducted over Zoom to work through scheduling conflicts.

Students		
Name:	Age:	Gender:
Ethnicity:	Major:	Socioeconomic status:
Hometown:	Homestate:	
Elementary Attended:		
Middle School Attended:		
High School Attended:		
Who raised you?		
What school/education values stick out to you as a child that were instilled by your parent(s)/guardian?	How did your parent(s)/guardian support you in your education?	Did your parent(s)/guardian play a role in how you chose your major?
What school education values stick out to you as a child that were instilled by your friends and community?	How did your friends/community support or created obstacles in your educational path? (i.e., stigmas, stereotypes, etc)	If you encountered obstacles in choosing a Physics major, described what these obstacles looked and how you overcame them or overcoming them?
What were the demographics of your elementary school?	What science do you remember being taught?	What did the interactions with your teacher teaching science look like?
What were the demographics of your middle school?	What science(s) did you learn? Was physics offered?	If physics was offered, did you take it? If not, why?
What were the demographics of your high school?	What science(s) did you learn? Was physics offered?	Did you have any counselors/mentors with helping you determining your major?

Teachers		
Name:		
Position:		
Grade/Subject you teach:		
How many years in field:		
School District:		
School Name:		
Educational Background:		

How do you determine for the school year what you will be teaching for math and science?	Do you have leeway in what you teach in these subjects?	Are there restrictions, and if so, what are they?
Do you notice any differences in the effectiveness of delivery amongst different demographics groups in your class?	Do you change teaching methods/strategies to accommodate those differences?	What resources do you have to supplement your teaching?
*If teaching ≤10 yrs	Can you give me your observations from past to present with changes in how STEM is presented in the schools?	
Principals		
Name:	School Name:	
Position:	Educational Background:	
Grade/Subject you taught:		
How many years in field:		
School District:		
How is the curriculum determined for your school?	Who has the final say on what is taught in the classrooms?	Does your school offer STEM-based classes? If so, are they offered at all or certain grade levels?
If STEM not offered, why and what are barriers preventing such classes from being offered?	What resources do you have for promoting STEM education, or math/science teachers? Where does that money come from?	Can you give me your observations from past to present with changes in how STEM is presented in the schools?

Materials

Material	**Description**	**Use in Project**
Zoom	Communication technology	Used to collect audio of each interview
Microsoft Word	Word processing program	Used to transcribe the audio from the interviews
Microsoft Excel	Spreadsheet editor	Used to organize data from interviews to code and find themes

Analysis

I transcribed each interview using the dictate tool in Microsoft Word and used Microsoft Excel to create a spreadsheet that I could compare similarities in subjects' answers to find common themes. I coded the information to draw connections between the data; this information was used to evaluate if any barriers exist that validate my initial expectations as well as previous studies and/or if there are any that I was unaware of. I can use this information to help formulate solutions to minimize or, if possible, eliminate the barrier(s). The end goal is to minimize or eliminate these barriers to see an increase in the diversity of the field of physics in the future. Some key themes that showed up as obstacles included limited access to physics education and quality education, lack of math proficiency, limited parental support, lack of mentorship as well as coping with mental health issues. Conversely, positive transitions into physics were characterized by themes such as financial support from family, self-motivation, and constructive influences from both peers and family members.

CHAPTER IV

RESULTS

To identify and evaluate more recent barriers experienced by underrepresented groups in STEM, I conducted semi-structured interviews with six Georgia Tech physics majors (undergraduates and graduate students) and six K-12 educators within the Gwinnett County School District.

The collected raw data is compared to secondary qualitative data from previous studies that identified obstacles not only for the general population of STEM students but underrepresented groups too. By uncovering these barriers, I hope to find viable solutions to minimize and/or eliminate the barriers to maximum participation of underrepresented groups in the future.

According to data collected by Integrated Postsecondary Education Data System, U.S. Census Bureau, and American Physical Society (Fig. 1), African-Americans aged 18-29 constitute approximately 14% of the population, with just over 3% earning bachelor's degrees in physics, and perhaps only 1% attaining a PhD. In contrast, the Caucasian population, comprising 16% of the same age group, exhibits a significantly higher attainment of both bachelor's and PhD degrees in physics.

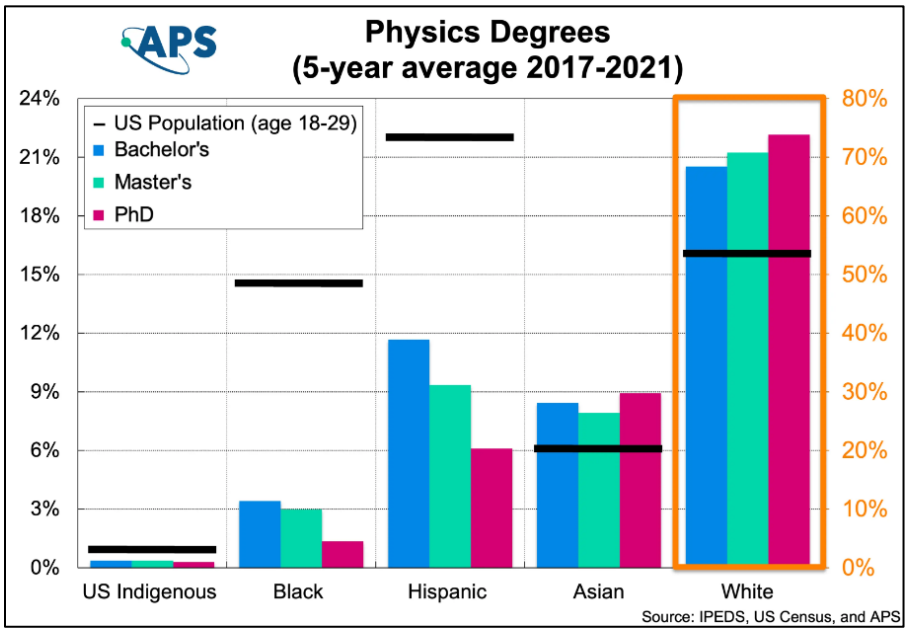


Figure 1 [16]: This graph illustrates a five-year average of the percent of physics bachelor's and doctoral degrees awarded to people of various races and ethnicities. Degrees awarded to temporary residents are not included in the calculations. Data on the college age population are collected from the U.S. Census. US Indigenous includes American Indians, Alaska Natives, Native Hawaiians, and other Pacific Islanders.

1.1 Interviews

The CRT analysis unearthed several key tenets, including colorblindness, interest convergence, and whiteness property. Interview responses are personally and professionally perceived individual, structural, and social barriers. These narratives spanned from students to educators, sharing their classroom experiences and perspectives, ranging from teaching to being taught in the fields of science and math.

1. Stereotype threats. A situational predicament in which people are or feel themselves to be at risk of conforming to stereotypes about their social group.

One Afro-Caribbean/African-American male undergraduate student mentioned that an obstacle that he perceived having while pursuing physics,

I guess one obstacle…just like feeling that you're inadequate or like not good enough.

Another African-American female undergraduate student expressed her concerns.

The only obstacle I thought of was being a black woman in STEM, but I knew I would be…because I just like STEM that much.

A study into CRT, unveiled a tenet that whiteness is a property. It was revealed that within schools and educational systems, the attributes associated with whiteness, such as rights of

disposition, rights to use and enjoy, reputation and status property, and the absolute right to exclude, play a significant role [1]. This is evident in school policies and practices that regulate the expression of minority cultures, as well as in the training and professional development of teachers.

2. Lack of access to quality education. The absence or limited availability of educational opportunities that meet certain standards of excellence or effectiveness.

One undergraduate's perspective about being offered physics in a private school that she attended.

> *I didn't know that you could have...physics in middle school until I like asked other people.*

Another undergraduate student's experience while attending public school.

> *...the only physics class I've had was during COVID and like 10th grade, so the class wasn't very good.*

Colorblindness idealizes the detachment of race from other social attributes and histories; nevertheless, it neglects the personalized and concrete underlying social truths. Consequently, this neglection impedes the resolution of injustices and perpetuates a system of white privilege. When teachers, whether consciously or unconsciously, fail to recognize race-related patterns in academic achievement and the potential influence of racism on the underperformance of students of color, it perpetuates harm within that demographic [1]. A Caucasian educator participant indicated that teaching methods may not be changed to accommodate demographic groups and that ways of learning have no bearing on race.

3. Physics perceptions in grades K-12. The collective understanding, attitudes, beliefs, and feelings that students, educators, and stakeholders hold towards the subject of physics within the kindergarten through twelfth grade educational system.

In every interview I conducted with undergraduate students, they universally shared experiences of not encountering physics instruction until their later years of high school. This observation coincides with the curriculum in Gwinnett County, where it is obligatory for each student to complete at least one physics course during high school, with physical science being the only science offering from K-8.

One Caucasian undergraduate female student recalls from elementary and living in a richer area.

> *…I do remember they did like a few astronomy, like classes or like projects…have little days where they go beyond and, teach you astronomy or something like that.*

And a Hispanic/Native American undergraduate male student who attended a majority white elementary school remembers being taught physical science, biology and earth science.

4. Lack of resources and funding. Insufficient availability of essential materials, facilities, personnel, and financial support necessary to provide quality education in schools situated in economically disadvantaged areas.

One K-12 educator and STEM instructor mentioned that an obstacle that she experienced while teaching in the classroom is not having the material needed for her curriculum.

> *My main restrictions are the lack of materials and supply…actual district they block so many websites…[that] gives me access to fun competitions for kids.*

Several K-12 educators mentioned in their interviews about an initiative funded by the federal government known as Title I. The aim of Title I is to provide additional funding to schools

serving a large population of economically disadvantaged students, aiming to support them in meeting state academic standards. There is also Title II funding that can be used to help enhance the professional development of educators, to ensure all students have access to high quality teachers [23].

A drawback with Title I as mentioned by a K-12 educator is that there is no leeway in how math is taught at her school.

> *Everybody across the board on 7th grade math needs to be working the same thing in that building.*

This could disadvantageous to the same group of kids that it is supposed to help, without having the appropriate preparedness of knowledge to build on, some of the underrepresents students are struggling to learn the curriculum and do not have strong foundation as they are required to move on to other material to stay on track with the District's pacing guide.

Consideration of Qualitative and Secondary Qualitative Findings

Interview findings supported and added to my secondary qualitative data. The Georgia Tech undergraduate students experienced similar or in some case different barriers on their journey to pursuing a physics degree. They identified with not experiences physics until high school and when they did take the course it may not have been the best experience. Educators in K-8 highlighted and supported limitations that were initially identified in areas of not having teachers equipped to teach physics subjects and not having the resources that supported and prepped their students for a physics track. The Gwinnett County pacing guide is the standard that the teachers are restricted to and most feel that they cannot deviate from it due to the alignment of the District's testing. Various barriers disproportionately impact underrepresented groups, while additional pressures,

such as the expectation to halt education after obtaining a bachelor's degree, was only noted by a Caucasian undergraduate physics student. Engagement from the school board and parents is pivotal in determining the quality of education throughout the Gwinnett County district. While Title I funding can alleviate some of the disparities, educators in lower-income community schools still face challenges in providing adequate resources to their students. Addressing systemic barriers rooted in racism and societal perceptions of inferiority will prove to be the hardest to change.

CHAPTER IV

DISCUSSION

The purpose of this research was to identify barriers experienced by Georgia Tech undergraduates and graduates on their paths to a STEM degree and what correlations may exist with gender, ethnicity, and socioeconomic status. The results of the study provided an overview of current Georgia Tech undergraduate physics majors and Gwinnett County School District K-12 educators. Interview responses from current students reflected that having strong family and community support were beneficial to exploring a path leading to a physics degree. Participants reported being introduced to physics in high school while one participant grew up with a parent that was a physics professor.

Quantitative findings showed that participants from different races attended schools where the demographics were majority white from K-12 or at some point during their school experience and demographics may have shifted.

Qualitative findings suggest that K-12 educators experience limitations with resources (e.g. restricted by standardized curriculum) in the classrooms as well as behavioral issues displayed by their students. While looking at the data for the undergraduate and graduate students' responses revealed that most did not receive a physics course well until high school. This supports previous studies that students not only received physics until high school, but the schools did not have teachers teaching physics that held physics degrees [13]. The study revealed that the Gwinnett County School District has a standardized guide for teachers to follow; however, due to COVID-19, teachers witnessed many students lacking the grade-level skills required for their students'

present grade. This required middle school teachers to meet students where they were and bring them up to the appropriate skill levels in some cases, while in elementary schools the study revealed that minorities were allowed to pass whether they learned the required curriculum or not. Another fact highlighted by educators was that Title I funding that is given to schools that have a certain percentage of students that are from low-income families, the funds help level the learning opportunities with those at higher income schools. While some teachers say that they were able to use these funds to get resources, like online accounts to programs such as I-ready to supplement their teaching, it was not revealed that this funding could be used to help implement physics courses in the curriculum and further research would need to be completed.

Undergraduate students had a broad range of perceptions, the study revealed that undergraduate students that identified as minorities did experience stereotype threats, while their majority counterparts' experiences were not subjected to this.

Limitations

In interpreting results from this research, several limitations were considered. While demographic diversity was used for the overall sample, it does not represent a large enough sample size to determine the generalizability of these findings to other students with different environments and upbringings that may not be representative of this sample group. While interviewing educators, they are bound to district standards and have no authority on policy changes and require observing the process within other school districts with the state or outside states.

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CHAPTER VI

CONCLUSION

Although efforts have been made to increase the diversity and retention of underrepresented minorities in STEM fields, these disciplines still reveal unequal race and gender representation [4][22]. By identifying these barriers, it will help to improve existing programs at federal, state, city, and county levels and eliminate negative societal mindsets among different groups to create a healthier and more inclusive environment. Strengthening diversity in STEM fields could bring innovative contributions that could help solve challenges in STEM.

The proposed goal was to collect fifty interviews from undergraduate physics majors at Tech and educators in Gwinnett County, but due to the brevity of the study, I only managed to conduct 12 interviews, which constrained the breadth of data necessary for a more comprehensive assessment of barriers. It is worth noting that even with fifty interviews, the chosen population sample may not provide sufficient depth to accurately capture the root causes of these barriers. I recommend a further and more in-depth investigation to identify the underlying causes of these barriers, leading the way for a more effective implementation of solutions and ultimately achieving higher success rates.

CHAPTER IV

FUTURE WORK

Addressing the barriers to STEM participation among underrepresented groups is not only a matter of social justice but also a strategic necessity to advance scientific innovation and societal progress. By uncovering the root causes of these barriers and developing targeted interventions, we can create a more inclusive and vibrant STEM ecosystem that harnesses the talents of all individuals, regardless of their background or identity. I believe to achieve this further work needs to be done by expanding interviews to include parents with K-12 age children, a wider pool of educators from different districts that represent the full socioeconomic ladder within the community, school boards, and minority high schoolers with opportunities to take physics dual enrollment courses with colleges and universities. These narratives will provide a deeper comprehension for understanding the barriers and appropriately implementing solutions that not only build a more diverse future for STEM but propel changes across multiple domains, such as societal equity, economic prosperity, scientific innovation, educational equity and policy and practices.

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