The Intersection of Identity and Performing Arts of Black Physicists

by

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Abstract

How one negotiates their physics identity is crucial to gaining and maintaining membership in the physics community. However, there is an exclusive culture of physics that has marginalized Black people and leads them to feel that they do not fit the criteria of who a physicist is supposed to be. Therefore, to understand what keeps Black physicists in the field, we must analyze their physics experiences. Studies show that the arts can act as an identity mediator or coping mechanism for underrepresented groups in STEM . In this work, we collect and analyze interviews of thirteen Black physicists, building on previous studies. We find themes in the ways that Black physicists participate in the performing arts. We map those themes onto the previously-developed Critical Physics Identity (CPI) framework in order to understand how the arts have impacted their physics identities. In this thesis we found that five of the CPI framework codes overlapped in our arts section. Secondly, four of the CPI framework codes used in the arts section had positive subcodes. Our last finding we found was a code connection relations among codes that appeared next to one another - sequential patterns.

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Philippians 4:13 I can do all things through Christ who strengthens me.

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Chapter 1

Introduction

In the United States Black people are underrepresented in the field of physics [1]. Due to this underrepresentation, the field of physics has been a perfect place to investigate the causes of these disparities. The American Physical Society gathered data on the proportions of physics degrees earned by different racial groups between 2013 and 2015 [2]. They compared these numbers to the proportions of these same groups in the college-age (20-24) US population. In the study, they found that Black students make up 15% of the population of US college-age students, however they make up less than 3% of the individuals who earn a bachelors degree in physics. In contrast, White students make up 55% of the population of US college-age students, yet they make up about 75% of the bachelor degrees earned in physics [2]. These statistics present the question: "Why is there a gap between Black and White students pursuing a degree in physics?"

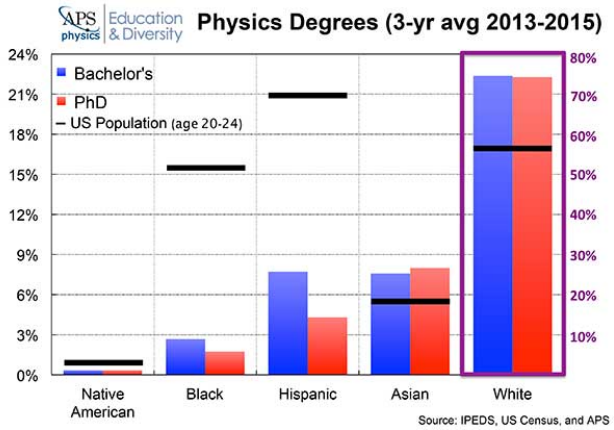

Figure 1.1: This graph illustrates the percentage of physics degrees, bachelors and doctorates, awarded to Native Americans, Blacks, Hispanics, Asian and White students between the ages of 2013 to 2015 [2].

These statistics point to the commonly-held idea that there are aspects of the culture of physics that marginalizes Black people. These aspects may sway Black individuals into thinking that they do not fit the criteria of who a physicist is supposed to be [3]. Typically, this can be from multiple forms of racial bias such as racial microaggressions or racial stereotypes, such as assumptions and myths about the academic abilities of certain groups of students, especially Black students and/or feelings of being personally diminished by White teachers and/or peers [3]. These racial forms of bias quiet often result in Black individuals questioning their physics abilities [3].

As a STEM (Science, Technology, Engineering and Mathematics) field, physics has a cultural and structural manifestation that has traditionally privileged norms of success that favor competitive, individualistic, and solitary practices, which are norms traditionally associated with White male scientists [4]. Many times, Black students alter their self-defined authentic identity in these environments and overuse their personal grit while pursuing a STEM degree. This usually results in exhaustion and thinking twice about their placement in STEM and most often that of physics [3]. These realities additionally affect women, women of color and racially/ethnically underrepresented students who are consistently marginalized [5]. However, despite these setbacks, there have been studies that show that underrepresented people have made an effort to study within these various STEM fields [5]. These efforts are often made possible by counterspaces. Counterspaces offer support and enhance feelings of belonging in STEM [5]. These are nontraditional groups that lie outside mainstream educational spaces such as conferences and campus-based groups that focus on STEM diversity [5]. Comparatively recently communities with the physics, focusing on education, have begun to address these challenges.

Physics Education Research also known as PER, is a fairly new subfield of physics that has made strives to increase its passion and learning ability to diversify marginalized and underrepresented groups in physics. Some broad examples of work that has been done in

the PER community encompass topics that touch upon cognitive and computational models of learning processes, or cognitive origins of student difficulties in physics.

The Physics Education Group at the University of Washington defines the goals of the PER community to develop and utilize theories and techniques that characterize, measure and influence the learning of physics by students [6]. PER is thought of as a community of practice. A community of practice is a group of people who share a concern or a passion for something they do [4]. They then learn how to do it better as they interact regularly with one another [4]. Because PER is a community of practice and the goal of PER is to learn about physics students, how one identifies as a physicist is connected to how they participate in the cultural practices and norms. Therefore, the investigation of Black physics identity is an important aspect of this community of practice. How one negotiates their physics identity is crucial to becoming a physicist and maintaining membership in the physics community [4]. Therefore, in order to increase the presence of minorities, especially Black individuals, in the field of physics there must be a further examination of physics identity.

In order to investigate Black individuals' physics identities, we must also investigate their racial identities. In this work, we use a framework of racial identity that consist of resources that have shaped a person's learning environment [7]. Racial identities can also be different depending on other intersectional identities like for any individual who identifies as Black, African and/or African American. Knowing this information, we use the resource framework to pick up on the differences in experiences amongst Black physicist who have different intersecting identities.

There is preexisting literature on identity and how it plays a role in the schooling of many students of color. For example "Becoming (Less) Scientific: A Longitudinal Study of Students Identity Work From Elementary to Middle School Science" by Heidi B. Carlone that focuses on understanding students claim to disliking science in middle school after loving it in elementary school, and if it was possible to probe in more deeply into the cultural (implicit)

meanings of science in their school [8]. However, this work does not look at how these identities can be supported.

There is however research that looks at how the performing arts can be characterized in a Black physicists identity in addition to the role the art's play. In our preliminary research [9] it was found that it is possible to characterize the role of arts participation of Black physicists. Through this research, we saw where the performing arts provides outlets of learning, expressing emotions and positive social interactions. There is also preexisting literature on the performing arts and how it is incorporated into science curriculum. In these studies, the performing arts have been used in science education to engage young people with science and increase science's values and its processes of research [10]. However, there is a lack of research in understanding the intersection of physics, the arts, and identity, especially those who identify as being Black. The performing arts can shed light on the change that can happen if we examined the intersection of these very different topics.

This thesis will explore the Critical Physics Identity Framework [11] and its intersection with the performing arts. Our goal in this research is to answer the question "How does the performing arts support the physics identities of Black physicists?" We will understand and discuss how Black physicists view the performing arts as physicists. First, we will present our research question. Then in the following chapters, we will first discuss important background information that supports this work. It consists of physics identity, racial identity, the Critical Physics Identity framework and the integration of STEAM. Followed by our method section which will answer our research question. Finally, we will conclude with our results and discuss future work from these findings.

Chapter 2

Background

Throughout this thesis, we will aim to understand how the performing arts support Black physicists. Understanding the different depths of a person's identity is an important part of this research. A person's identity spans a broad spectrum of categories, from gender identity to academic identity. These identities are what make each individual unique. In this section, we will give background on two types of identity that are critical in our research. In addition to discussing identity, we will explain the framework that is used for understanding not just physics identity but racial identity as well. In the last section, we talk about preexisting literature on the intersections of art and science, or STEAM and how it is relevant to our work.

2.1 Identity

Identity is defined as an individual's collection of cultural factors such as sociodemographic conditions, social institutions, cultural upbringing, significant others, practices and activities [12]. In other words, "identity" is not one specific thing, but a social construct that refers to a vast set of phenomena which in some cases can be quite complex [11]. We like to think about identity as ones sense of self, that is continuously shaped by their environment [12]. Different categories of identity can be black identity, gender identity or political identity; there are a large number of identity categories. Additionally, a person's identity is not limited to just one category of identity.

Overall, identity is a conceptual idea that contains, connects, and enables reflection over the emotional and cognitive processes of self-understanding and self-defining, in the past as well as in the present and future [12]. Culture is used everyday and continually shapes a

person's perception about their environment. This can be through questioning tradition, cultural communities or experiencing events in different particular ways [13-14].

Identity should not be mistakenly viewed as being solely what individuals fix in their minds to believe. It should be viewed as social products that are embedded in one's culture that helps to define oneself [12]. One's cultural background, has a major impact on one's identity. When culture sways a persons identity it begins to make up a person's racial identity. A person's mindset is not the only contribution that impacts the way a person defines themselves in society. It is sometimes not recognizable but people define themselves through other people, and resources both visible and invisible. Social relationships, significant others, activities and practices, political ideologies, religious beliefs are examples of resources for making and expressing identity [12].

An individual's identity crafts the way that a person learns [12]. These identities are accumulated through beliefs, ideas, skills and abilities. The funds of knowledge approach lies at the intersection of these identities stating that family members and their community are valuable to a person's education resource [12]. A teacher can use a student's identity to teach biology or mathematics through funds of identity. A self-lived experience is one example of funds of identity. Many times a person's family or community are valuable educational resources that can be assumed as funds of knowledge [12]. By a teacher understanding a student's background and the type of resources, such as library or extracurricular programs that may be available to this student, a teacher can then adjust their teaching type in order to help this student succeed. Funds of knowledge are useful tools when understanding a person's identity, and can be very helpful in understanding the complexities of these identities.

Overall identity is an idea that connects individuals to things that they learn throughout their lifetime. These self-lived experiences shape a person's beliefs, ideas and abilities. A persons identity can be influenced by others who may have a significant impact on them. This fundamental context of identity, is key to understanding the two categories that encompasses Black physicist identity. The first is physics identity which looks at a persons identity within

the field of physics and the second, is racial identity which looks at a persons identity with their respective racial groups.

2.1.1 Physics Identity

As defined earlier in the introduction section, the physics education research community also known as PER, is thought of as a community of practice, a group of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly [4]. The PER community gives us the resources to fully do investigative research in other fields of physics, such as diversity outreach in astrophysics or applied physics. One of the main motivations of the PER community is to understand student trajectories into the field through the construct of identity [11]. Understanding a person's physics identity can shed light on reasons why students remain in the field or not [15-17].

An important aspect to understand about the physics community is that although it is a community of practice we must remember that it is also a socially constructed by the people within the group [4]. Therefore, the investigation of physics identity must be studied in the group that defined itself. Additionally, in the realms of community of practice, it is important to be able to negotiate between different locational settings [4] these settings can include college life and/or cultural life. Therefore, we must take into account personal and cultural identities, when looking at a person's physics identity [7]. When we do not look at personal and cultural identities in physics, it is doing a disservice to minorities not represented in these groups. The entire culture of physics continues to be defined by the people who dominate the field, white men. Because of this, our work looks to investigate the marginalization of Black physicists, and our research team includes underrepresented minorities in physics.

In the broader field of science, there is research that has focused on science identity by Carlone & Johnson, where they have developed constructs for science identity [18]. The authors, questioned how women of color experience, negotiate, and persist in science. The

authors find it essential to get a better understanding of women's meaning of science and of themselves as budding science professionals evolving over time. An identity lens allows for the researcher to ask questions about the kind of people marginalized by science teaching, students' emerging identities in science might involve changes in who they are and who they want to become [18]. The model of science identity constructs were important in establishing a dual focus on the agency of those striving to build a science identity and the constraints on that process due to the structures within which that identity is being constructed [18]. These constructs include recognition, performance, and interest. In relation to our work, we pull from these constructs of science identity, to help build a stronger understanding of Black physicist and their own stories.

Hazari et. al. took the Carlone & Johnson model and applied it specifically to physics to investigate how students physics identities are shaped by experiences in high school physics classes and their career outcome expectations. The explicit discussions of underrepresentation of women in science was positively related to physics identity for women students but had no impact for male students [19]. The authors stated that statistically physics has failed to increase women's participation and continues to suffer with low woman undergraduate graduation percentages [19]. Hazari et. al. research results stated that for it is important to focus on conceptual understanding and real-world/contextual relevance [19]. Finally, they conclude that physics identity and, more generally, science identity provide fruitful directions for new research. The conclusion gives relevance to our research of investigating Black individuals' physics identities.

The physics identity framework developed by Hazari includes the constructs of interest, competence, performance, and recognition. Interest is defined as a curiosity desire to think about and understand physics. Performance is defined as belief in ability to perform required tasks. Competence is belief in ability to understand physics content. In our research, performance and competence are defined together. Finally, recognition is defined as recognition by

others as being a good physics student. When an identity framework is used, we recognized that identification with physics is only one small part of a person's identity [19].

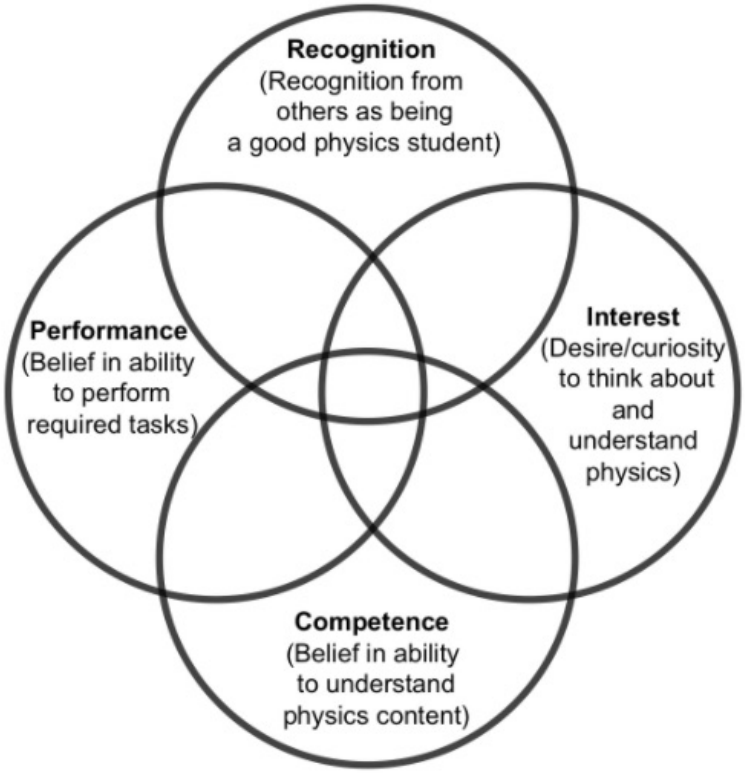

Figure 2.1: Physics Identity framework developed by Hazari et. al. [19] that was built off of Carlone's Science Identity work.

The physics identity framework provides a centralized structure which provides us with a wide range of research results that focus on persistence in science [19]. Additionally, the framework provides an understanding of how students see themselves in relation to the field of physics based on their perceptions of physics and their negotiation and navigation of physics everyday [21].

2.1.2 Racial Identity

Historically, identity is linked to the work of Erik Erikson, who originated the term "identity crisis" [22]. Erikson's basic domains of identity focus on developing commitments in the areas of fidelity, ideology, and work [23]. When speaking of identity in particular, we

are concerned with how individuals select, choose, and commit to different people and idea systems in the course of their activities [23]. Identity research must examine contexts in which identity is contested or under transforming shifts. However, his work fails to include cultural and racial context to a person's identity.

Another approach to identity is that of Brown [24]. In his work, Brown creates a representation of identity in an interpretive framework. This framework looks at how individuals take on different scopes of themselves without the overbearing influence of racism. The figure below is a construction of the possible sources of a Black person's identity.

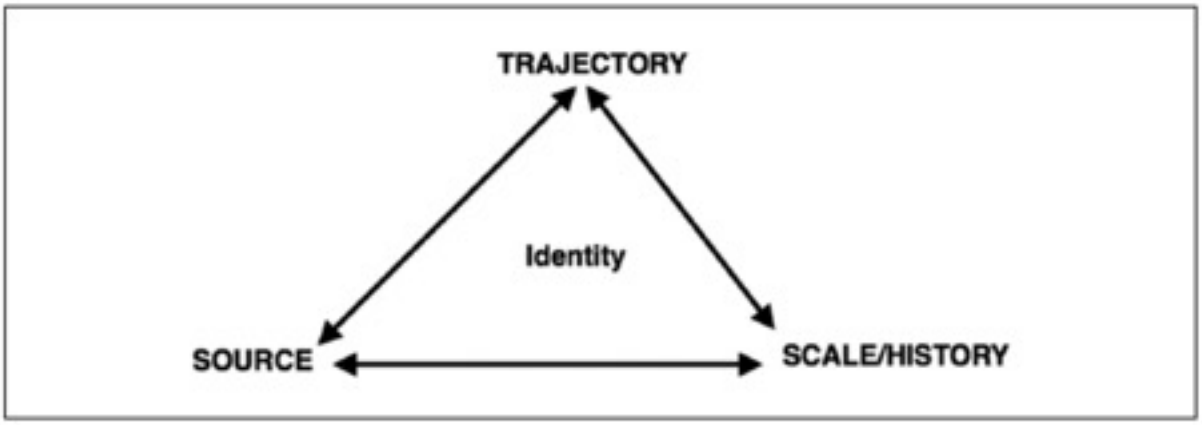

Figure 2.2: Representation of identity interpretive framework [24].

Source is broken down into four types of identities; nature, institution, discourse and affinity [25]. A nature identity is where an individual's identity is determined by a natural phenomenons [25]. An example of a nature identity would be if a person was an only child. An institutional identity is when an individual identity is defined through participation at an university and/or organization [25]. An example of an institution identity would be whether a person was a college senior. Discourse identities are identities that label or describe a person's identity [25]. An example of discourse identity would be if a person were "intelligent" or "witty". Affinity identity are identities that share attraction to things [25]. An example of an affinity identity would be if a person likes to spend time with individuals who were "hikers" or "videogamers" [24-25].

The scale of a person's identity highlights the timescale and options a person can take. For example, being a Black woman physicist in the 1950s would offer different career or educational opportunities compared with 2018. Trajectory is defined as aspects of a person's identity which shape their goals. A scenario that Brown presents, is if two people enter college wanting to be a physician, however one comes from a family of physicians while the other is a first generation student. They both have similar goals; however their backgrounds affect their trajectory [24-25].

Scholars have posed identity as a way to understand how the "who"of a person can become a source of empowerment [26]. Brown states that identity has been cast as a medium where the individual has agency to take on the dynamic or limited possibilities that lie before him or her. Additionally, Brown brings light to the work of Spencer who stated that the perceived assumption that African Americans must deal with "competing allegiances" [27]. This is where institutions leave little room for students to be seen as smart and Black and that if they pointed out their racial identities they'd be more adept at merging them [27]. However, because of racial bias many individuals must pick between being academically strong or being Black [24, 27 & 28]. Brown uses this background work to investigate how institutions can create spaces for healthy racial identities based off a persons source of identity, trajectory and scale/history [24].

These frameworks highlight the importance of being conscious about the identities of Black individuals, we need to keep in mind that there are different types of Black identity. For example, a person who is from Ghana would have a very different outlook of physics compared to a person from the US [10]. While studying identity we need to account for intersectionality a lens which you can see where power comes and collides, and where it interlocks and intersects [30]. In terms of identity, a term coined by Kimberl Crenshaw, intersectionality accounts for individuals having a web of identities that interconnect and influence their perspective or outlooks on physics. For example their political identity, their academic

identity or their gender identity. Any work that does not account for intersectionality cannot sufficiently address the manners of Black individuals [31].

Another framework that exist in examining racial identity is the work of Nasir. She looks at racial identity in the context of math education [7]. The author analyzed the experiences of Black high school students in different learning environments [7] to identify the three main constructs that make up a person's racial identity. These three different constructs make up her framework: **material resources**, **ideational resource** and **relational resources**.

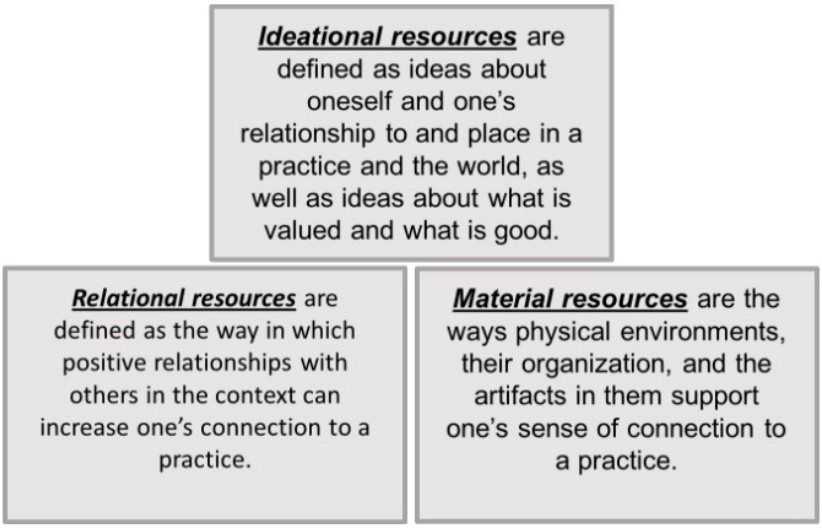

Figure 2.3: Definitions of Nasir's [7] racialized identity resource constructs.

Nasir defines material resources as things that can provide access to other identity constructs. For example, programs, organizations and funding. Having access to public libraries and STEM program illustrates material resources. Ideational resources are defined as aspects of an idea that impact one's connection to a person's identity. An individual can personally know whether or not they are interested in a particular subject or activity. Lastly, relational resource are defined as the way in which an aspect of a relationship with others in the context can impact one's connection to their identity. A high school science teacher can be impactful on a student's development in liking or disliking the sciences. Nasir's framework illustrates how a person's racial identity is dictated by different learning

environments, however it does not work to include racial identity in the context of physics education.

2.1.3 The Critical Physics Identity Framework

The Critical Physics Identity or CPI is a framework and methodology for understanding physics and racial identities. This is a framework that merges racialized identity resources [7] and physics identity constructs [19]. This framework was designed to highlight the institutional systems and structures that impact the experience of physics along their career trajectory. Additionally, we use the racialized identity framework with the idea that students' racial identities precede any scientific or academic identities, and a physics identity must be negotiated in conjunction to it [32].

In this particular work we used the CPI framework to highlight more external, ideological, and material aspects or facets that can affect how one builds an identity as a physicist. The two frameworks of identity of Nasir and Hazari [7 & 19], when used together will show how physics identity differs for physicists across all racial and ethnic backgrounds, and will further help us to gain a comprehensive understanding of the facets of identity that are relevant in a physics identity [32].

Relational Resource	Material Resource	Ideational Resource
Recognition	Performance/Competence	Interest

Figure 2.4: The Critical Physics Identity Framework.[11]

The difference between the original physics and racialized identity frameworks and the CPI framework, is that it expands on these constructs by identifying subcategories such as positive, negative, internal, external which help to paint a clearer picture of the experiences of Black students to professionals in the physics field [11].

A relational resource is defined as the way in which an aspect of a relationship with others in the context can impact ones connection to physics [11]. A relational resource can be a teacher, peer of mentor that has influenced a person to pursue physics. The relational resource construct has a positive and negative subcode. The positive and negative subcodes focuses on whether this resource was encouraged or discouraged to these individuals physics identity [11].

Code	Subcodes
Relational Resource	Positive
	Negative
	Neither

Figure 2.5: Relational Resource and its subcodes from the CPI Framework [11].

An ideational resource is defined as aspects of an idea that impact one's connection to physics [11]. The ideational resource construct has an internal and external subcode. These subcodes address what the interviewee's thinks about their physics identity and what others think to these individuals physics identity. In addition to these subcodes it is important to understand that our ideational code and interest code have subcodes that are more specific in helping to understand the narrative of these physicist. For our ideational resource, these subcodes include: positioning in physics, whats valued and good in physics, personal characteristics, and perceptions of physicists.

Code	Subcodes	
Ideational Resource	Positioning In Physics	Internal
		External
	What's valued/good in physics	Internal
		External
	Personal Characteristics	Internal
		External
	Perception of Physicist	Internal
		External

Figure 2.6: Ideational Resource and its subcodes from the CPI Framework [11].

A material resources is defined as material things that can provide access to other identity constructs. Some examples of material resources include physics programs, community outreach physics organizations and/or science funding [11]. The material resource construct has a positive and negative subcode, like the relational resource construct. The positive and negative aspect focuses on whether this resource was encouraged or discouraged to these individuals physics identity [11].

Code	Subcode
Material Resource	Positive
	Negative
	Neither

Figure 2.7: Material Resource and its subcodes from the CPI Framework [11].

Recognition is defined as being recognized (or not) as a physicist or physics person [11]. The recognition construct has an internal and external subcode. These subcodes address whether the interviewee view themselves as physicist or whether others view the interviewee as a physicist. The positive and negative aspect focuses on whether these recognitions were encouraged or discouraged to these individuals physics identity [11].

Code	Subcodes	
Recognition	Internal	Positive
		Negative
		Neither
	External	Positive
		Negative
		Neither

Figure 2.8: Recognition and its subcodes from the CPI Framework [11].

Interest is defined as interest in the physics field [11]. Its subcodes include: content and non content, that may have gotten these individuals interested in physics [11]. An example of an interest would be someone saying that they grew up watching shows about astronauts and because of that they wanted to study astrophysics.

Code	Subcodes	
Interest	Content	Positive
		Negative
	Non Content	Positive
		Negative

Figure 2.9: Interest and its subcodes from the CPI Framework [11].

The last construct in the Critical Physics Identity framework is the two combined codes of, performance and competence [11]. Performance/competence is defined as ones beliefs

in their ability to understand physics content and perform required physics tasks [11]. The performance/competence construct has a positive and negative subcode. The positive and negative subcodes address whether the interviewee mentioned having good performance ability or poor performance abilities in physics [11].

Code	Subcode
Performance/ Competence	Positive
	Negative
	Neither

Figure 2.10: Performance/Competence and its subcodes from the CPI Framework [11].

The Critical Physics Identity or CPI is important in our methodology for understanding physics identity. It is a crucial component that will support our research question in understanding the ways in which the arts impact Black physicist. It will further help us to gain a comprehensive understanding of identity when applied to the performing arts.

2.2 STEAM

The integrations of arts into the STEM fields is called STEAM (Science, Technology, Engineering, Arts, Mathematics) a new term that is helping to change how subjects in STEM are taught. It was popularized during the Maker Movement, to emphasize the role of design and creativity in many science and engineering projects. However, when we discuss the role of arts in this paper, we will mean that of the performing arts. The performing arts include music, dance and theatre arts. One particular reason to why we focus on performing arts rather than visual arts is because in visual arts, there is a tangible media that can show a

person's emotions or feelings, in comparison to performing arts where the individual must express their emotions and feelings through their physical actions. In my own experience in participating in the arts I can attest to the arts providing me with a space where I can be creative and vulnerable. The arts make ideas and theories, particularly complex ones, seem more comprehensible to students as more active involvement in learning is engendered [9]. Because of these reasons, we focus solely on the performing arts. Individuals who are creative thinkers and problem-solvers may gain many advantages by being involved in arts training such as music, dance and theatre.

There is literature that shows that the arts can have an impact on individuals under the subjects of STEM, like in "Drama and Learning Science: An Empty Space?" by Martin Braund [18] or "The PERFORM project: using performing arts to increase engagement and understanding of science" by Jon James [9]. These articles encompass how arts are being incorporated into student learning concepts. Incorporating an artistic component to science curriculum, especially that of physics, can be a useful tool when learning science in an informal environment. For example the PERFORM project, aims to humanize science in secondary schools in France, Spain and the UK [9]. In France they use clowning, in Spain they use stand-up comedy and in the UK they use street theatre [9] to teach sciences. However, there are few if any pieces of literature that highlight how the arts have helped play a role in an individual's physics identity. The incorporation of arts can bridge science culture and identity with nontraditional students in the field of physics.

Overall, there are informal and outreach programs that use STEAM, to teach STEM content and increase interest in STEM [34]. Additionally, STEAM is slowly becoming the norm in many classrooms and changing the way that people see the sciences. There is still space for more research to be done on the impact of STEAM.

In parallel, there are studies that show that the arts can act as an identity mediator or coping mechanism for underrepresented groups in STEM [10 & 35]. Arts are very similar to what counterspaces provide to many women of color in STEM. Counterspaces are areas that

many individuals, especially those in physics, create to help cope with challenges and stresses, such as pursuing a physics degree [5]. STEAM can be built as a counterspace however it is not necessarily have to be held as a defacto. When done appropriately the performing arts can be used to create a counterspace. Understanding that the performing arts are counterspaces is also very important in the STEAM narrative. This is because counterspaces promote their own learning wherein their experiences are validated and viewed as critical knowledge [5]. The performing arts, can be a place for Black physicists to vent frustrations by sharing stories of isolation, and establish and maintain a positive collegiate racial climate for themselves [5].

This study combines these frameworks and ideas to answer our research question. Understanding the fundamental qualities that make up a physics and racial identity are important aspect of this research. The CPI Framework merges both racial and physics identity to highlight structures that impact the experiences of our physicist. The understanding of STEAM being a useful tool in STEM, validates the work that this thesis encompasses.

Chapter 3

Methods

3.0.1 Research Question

The main question that we ask is: "How do the performing arts support the physics identity of a **Black physicist**?" We are hoping that our research question, will allow us to learn something different about our CPI framework and how Black physicists use and engage in the arts.

3.0.2 Objectives

The motivation for this research is to see how the performing arts supports Black physicists. During my time at the University of Colorado Boulder, my research focused on "Characterizing the Role of Arts Education on the Physics Identity of Black Individuals" [10]. In this preliminary study, I looked at a subset of this data and found themes that related to how the physicists talked about the arts. These findings consisted of an increased physics ability, the arts being a better social environment than physics, the arts have a significance in the participants experience and lastly the arts being a coping mechanism.

After analyzing these arts sections, I saw a correlation between many of these findings. This correlations resulted in me creating a coding scheme to analyze these STEAM sections that was different from the CPI framework.

However, this coding scheme only looks at the arts and how they play a role in a Black physicist's arts education. The work that we are doing now is mapping the CPI framework onto a larger set of interviews to understand how participation in the arts impacts one's physics identity.

The goal of this work, is two-fold: 1) to analyze the impact of participation of performing arts on Black physicists and 2) using the CPI Framework to analyze interviews overlapping with our STEAM code; to determine if participation in the arts impacts Black physicist identity.

In order to achieve these goals we will use the CPI framework to analyze interviews with Black physicist and lastly we will present findings on how participants use the arts to support their physics identities.

3.0.3 Data Collection

This project focuses on Black physicists from different parts of the world. It is to be noted that even though participants may be from different nationalities all research is being done in the US and within US context. In total, there are thirteen interviews used in our research project. We define a "physicist" as an individual who is close to obtaining or has already obtained a bachelor's degree in physics, or who has already obtained one. Our participants range from senior undergraduates, graduate students, postdocs, and professional physicists. These individuals may identify as Black, African American, Caribbean and/or African. Each of these physicists have their own personal experiences of learning physics. Many of the individuals that we have interviewed we're sought out at national conferences, were recruited via Black physicists organizations or have worked with us at our various institutions.

We have developed an interview protocol that prompts interviewees to tell their experiences and what it means to be a physicist. Our protocol questions are semi-structured, this gives the interviewees the liberty to focus on their physics and artistic identity intersections without the interview being too rigid. Our CPI methodology uses narrative inquiry, which intentionally is designed to prompt stories.

Our data collection for this study was done through an interview process. The interviews were primarily conducted by one member of our research team who also identifies as a

Black physicist. I had the chance to conduct an interview that we use in our research. A typical interview lasts between thirty minutes to an hour. At any point of the interview, when we wanted to understand the interviewee's perspective more, we encouraged them to expand on their experiences. These interviews were ideally done in person using a recorder. If the interviewee was not accessible to meet in person we used Zoom. Zoom is a video communication app, used for video and audio conferencing, chat and webinars. There are about 15-20 protocol questions for the entire interview process, however in this work we focus on the arts section. Some questions that are included in the interview protocol are: "Have you ever participated in any performance art in your past or currently?", "In what ways has participating in the arts benefited you?" and "What have you gained from those experiences?". These are just some of the questions that we ask our interviewees. After the interviews were conducted the participants were asked to complete a demographic survey, so that the questions regarding demographics in the interview did not impact the participants overall interview.

Our interviews are analyze using a narrative inquiry lens. It is used broadly in qualitative research, to help understand and give meaning to people's stories [36]. Many educational experiences studies use narrative inquiries [36]. Narrative inquiries give us the ability to see connections between this person's physics identity and the resources that may or may not have contributed to their identity. It gives premise on the idea that people give value to their experiences through how they tell their narratives. Narrative inquiries see stories as we imagine them functioning in educational inquiry and generate a new a agenda of theory-practice relations [36]. By listening to participants stories of their experience of teaching and learning, Connelly states he hopes to write narratives of what it means to educate and be educated. Narrative inquiries are an important tool in understanding identity [36]. To gain information from many our participants there must be some storytelling to get a clear understanding of their background their journey with physics.

After we had all the required information for the interviews, the audio files are transcribed by a transcription service, who are not familiar with our work. All transcripted interviews and the participants information is kept in a shared Google drive folder with the project team.

3.0.4 Analysis Process

The coding program that we used for all our interviews is MAXQDA12. MAXQDA12 is a software program designed for computer-assisted qualitative and mixed methods data, text and multimedia analysis. It is developed and distributed by VERBI GmbH based in Berlin, Germany.

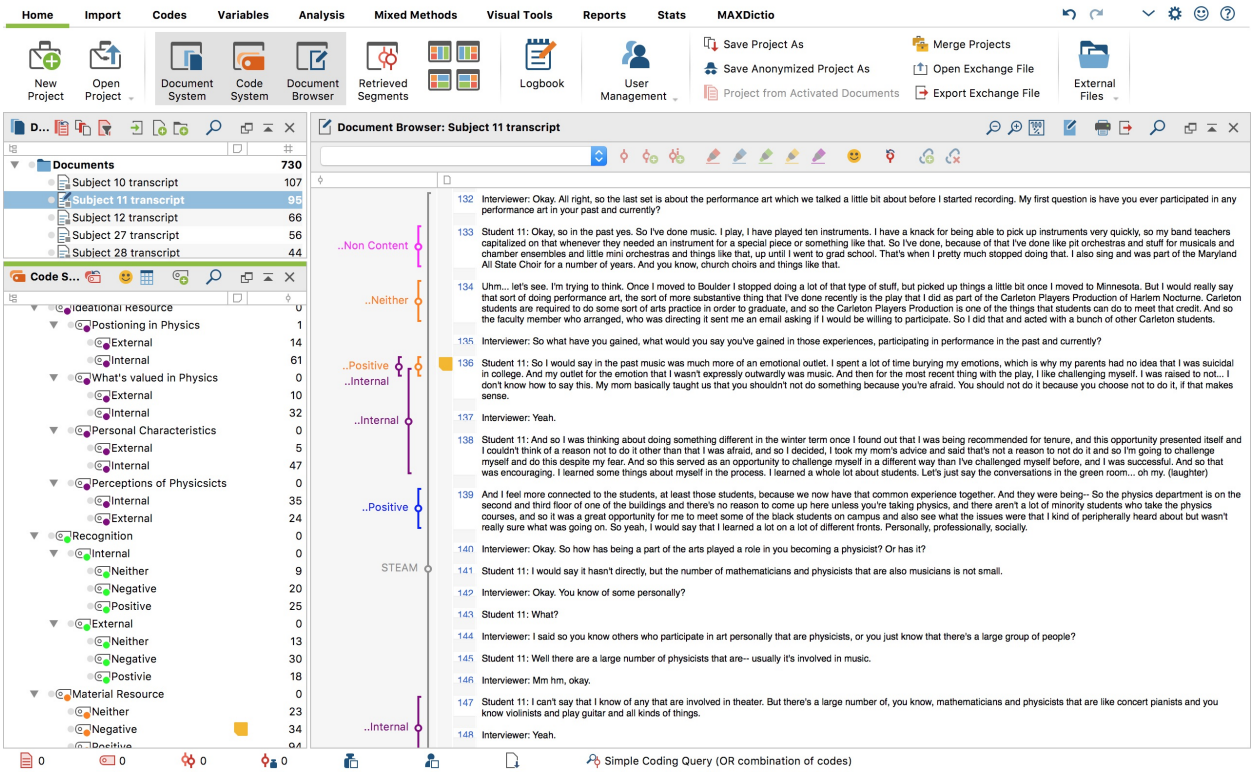

Figure 3.1: An excerpt from Subject 11's coded interview in MAXQDA using the Critical Physics and the STEAM code constructs.

Our process includes individuals coding, comparison, and group discussion for consensus on code definitions. One or two individuals code separately without discussion. We began

with one interview and the definitions in the framework to code areas that are perceived to be with any of the occurring themes. For example, if an individual states "I got into physics because of my high school teacher", we code this statement as a relational resource. We then code an additional interview from a different participant. After, we as a group agree and discuss if our codes should be better refined. For instances where it is unclear if a statement is a particular code or codes, we collectively discuss if certain codes reflect the interviewees initial intentions. Below, is an illustration of how we use MAXQDA to help analyze our interviewees interviews.

Our coding team consist of a White woman, a Latina woman and two African American women. Having these different backgrounds helps to shape the narrative and solidify the interpretation of each participants interview. Many of the experiences that are iterated in these interviews are very similar to our research team and therefore we are better equipped and conscious when we are coding. We also allow for a diverse coding team so as to minimize bias in our coding results.

After the coding and discussion is complete we use an inter coder agreement. A Cohen's kappa coefficient κ is a statistic which measures inter-rater agreement for qualitative data [37]. The κ value represents the extent to which the data collected in the study are correct representations of the variables measured. The kappa coefficient measures the degree of agreement between 0 means to 1 means [37]. 0 means that there is no inter-rater agreement and 1 means 100% inter-rater agreement. Our inter coder agreement had a κ value of over 0.8 for all of the interviews.

One of the key aspects that consistently showed up in our analysis were overlapping codes. Overlapping codes are when one or more of our CPI framework codes and STEAM code, are coded in the same region of an interview. These overlaps show up consecutively especially since these interviews are in the form of narratives. We run a test in MAXQDA that shows us where the codes connect and overlap. We use the code relation browser, to see

how they show up consecutively, one after another, in a narrative. From these recurrences, we gather our findings and themes from this data.

3.0.5 The STEAM Code

The STEAM code that we use in our coding process is not a part of our Critical Physics Identity framework. Rather it is a code which we use to help classify a section of our interviews where we ask questions about the performing arts. As mentioned earlier, the STEAM code (Science, Technology, Engineering, Arts and Mathematics) flags questions such as "Have you ever participated in any performing arts in your past or currently?" to "Do you think that the arts have impacted your career as a physics?" Having the intersection of the STEAM code and the Critical Physics Identity framework will show us a unique narrative about how these physicists use the arts. The point of the STEAM code is to use the co-occurrence tool to collect and aggregate the CPI codes that show up in the sections of the interviews that talk about the arts.

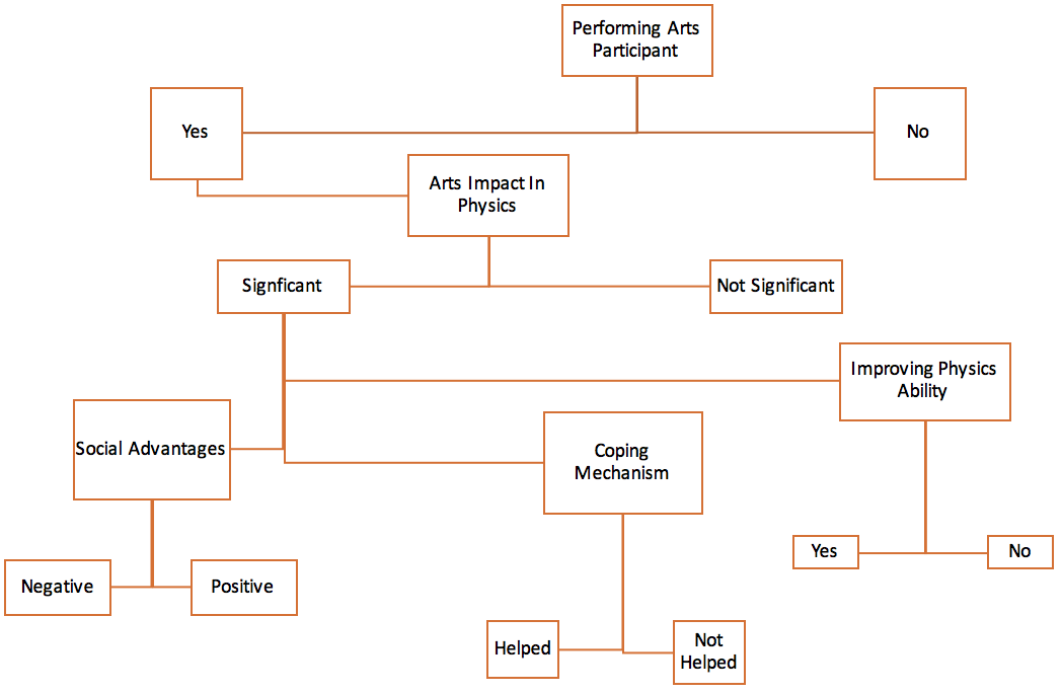

Figure 3.2: Characterizing the Role of Arts Education for Black Physicist, Framework Construct [10].

These sections of the interviews were previously analyzed in research which characterized the role of the arts in the lives of these physicist. The image below shows the outcome of our preliminary research on "Characterizing the Role of Arts Education for Black Physicist".

3.0.6 Coding the Interview

As mentioned throughout this paper our interviews are coded with the Critical Physics Identity framework. Below I will walk through an excerpt of an interview to illustrate how we code these interviews with our framework. These excerpts were taken from sections were there are multiple constructs that overlap with one another. Viewing these sections will help us to understand how these constructs shape the narrative of these interviews.

In this interview, we see how Subject 31, revisits some of the performing arts that they may have participated in the past or currently. The interviewer begins the conversation with asking the question "Have you ever participated in any performance arts in the past or currently?". Subject 31 responds "Yes", and in order to hear more about our interviewees experience the interviewer prompts the interviewee to elaborate by stating "Tell me about that." In this except from Subject 31's interview, shown in the figure below, they tell their story about their past performing arts career.

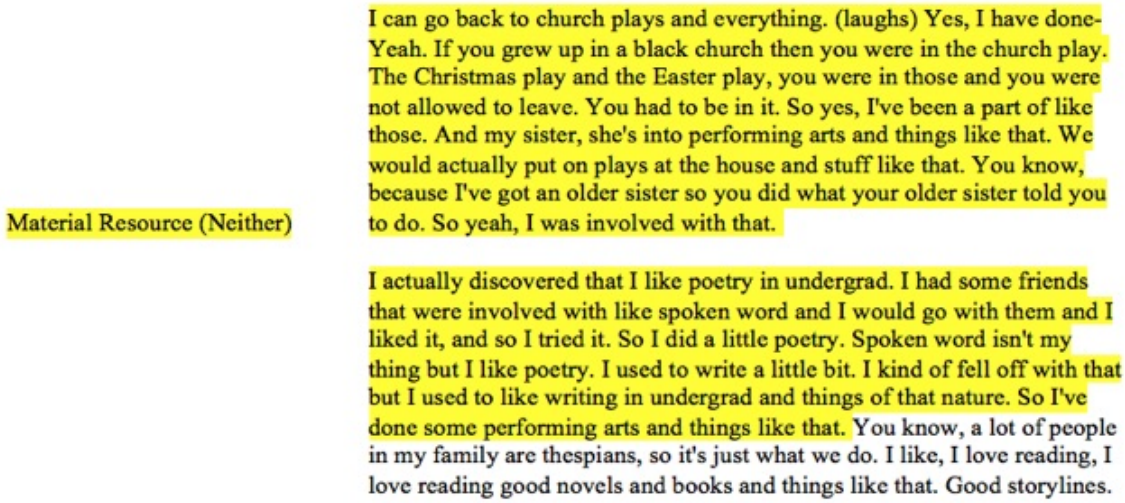

Figure 3.3: An excerpt from Subject 31's coded interview of a material resource.

This response was coded as a material resource "neither" and our STEAM code. Any type of performing arts a person speaks on is a material resource. It was coded as neither because it does not connect back to this person's physics identity. Subject 31 continues to elaborate on their artistic identity, which is still marked as a material resource, neither. They state how they discovered a like of poetry, another form of the performing arts.

The interviewer goes on to ask "What have you gained from your experiences with the arts?" In the figure below we show how we coded this section of the interview as an ideational resource.

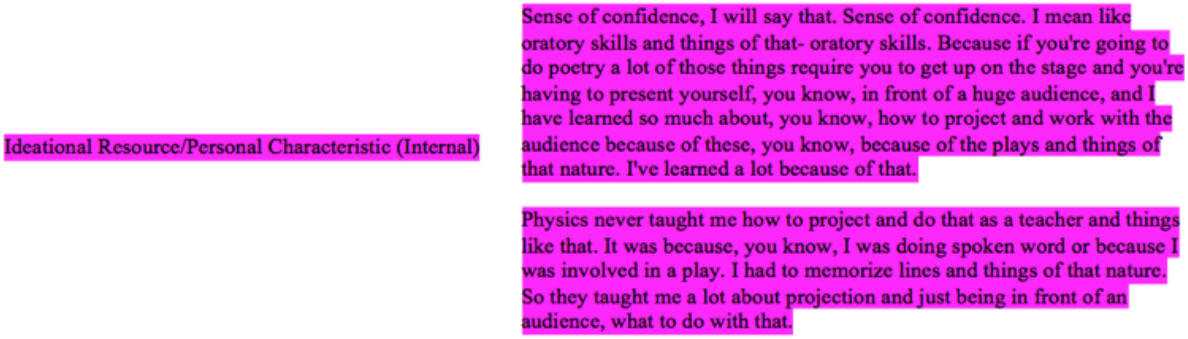

Figure 3.4: An excerpt from Subject 31's coded interview of a ideational resource.

The interviewee says that they gained a sense of confidence, oratory skills. Additionally, they state sometime uniquely interesting, that physics never taught them to have a sense of confidence. This section was defined as an ideational resource, with a subcode of personal characteristic. This is because the interviewee found something about themselves that was life changing.

In the next section of the interview, the interviewer ask the protocol question "How might have these things played a role in you becoming a physicist?" In the figure below Subject 31 goes to say learning intuitive skills in the arts have helped played a role in this person becoming a physicist.

This particular section was coded as performance/competence because the interviewee speaks upon skills that has help them to understand physics better. This section is coded

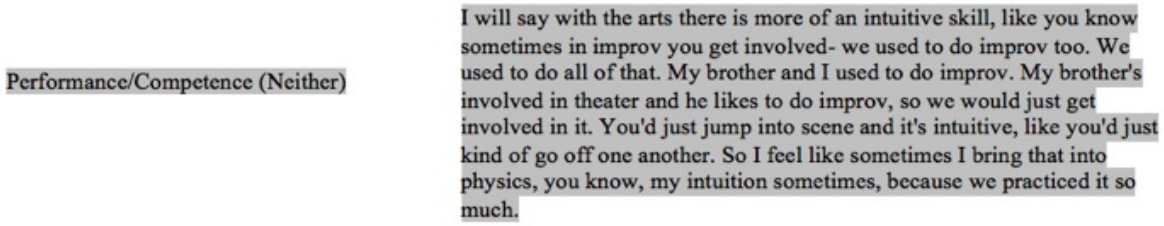

Figure 3.5: An excerpt from Subject 31's coded interview of a performance/competence.

additionally as neither, because they dont state that it was a positive or negative experience but rather a skill that was useful to them to apply in physics.

Another coding example can be seen when Subject 31 responded to the question "Could you see yourself in physics without having participated in the arts or without ever participating in it?" The figure below shows how we coded their response to the interviewer's question.

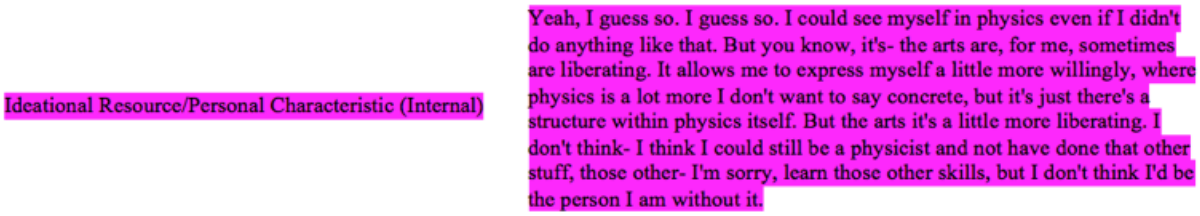

Figure 3.6: An excerpt from Subject 31's coded interview of a ideational resource.

Subject 31 states that they could see themselves as a physicist without the arts, however they go on to say that the arts are liberating. This section was coded as an ideational resource being that it is an internal personal characteristic. They found that the arts have personally allowed them to express themselves a little more than physics.

Chapter 4

Results

There were three major findingd from this research. First, we found that only five of the CPI framework codes overlapped in the STEAM section. These codes included the relational resource, the ideational resource, the material resource, the performance/competence code and the interest code. Recognition had no presence in our STEAM section. Our second finding in our analysis process showed that most of the CPI codes used in the STEAM section had positive subcodes. The third finding is that we found relations among codes that appeared next to one another, these codes often included sequential patterns. These were sequential code patterns of an interviewees narrative that elaborated on an experience or idea. These three findings will be explained in more detail in the following sections.

4.0.1 Code Counts

The first method for analyzing the coded interviews was to look at the number of times we coded each CPI construct in the STEAM sections of the interviews. We call these the code counts, and they can be found below in the graph in Figure 4.1.

In our analysis process we found that there were seven occurrences where our relational resource code overlapped with our STEAM code across three interviews. The individuals who showed relational resources in their interviews iterated that they meet different people participating in the arts and created a community within their various performing arts disciples. Subject 33 states:

> *"I would say you get a sense of community and you get a sense that there's more to the world than just your occupation or what you're in. Like a part of the reason why I don't say I'm a physicist is because that's not my ambition for life, like that's*

not the thing that I'm- that may be the thing that I'm involved in at some point, but you've got to kind of step outside of those bounds. And I think being involved in arts and I guess the spoken word things that I do sometimes, that just helps me relate to people."

From this we can conclude the arts can produce meaningful relationships, which may be unlikely to find within physics. These relationships provide a different sense of identity that isn't physics or occupational based.

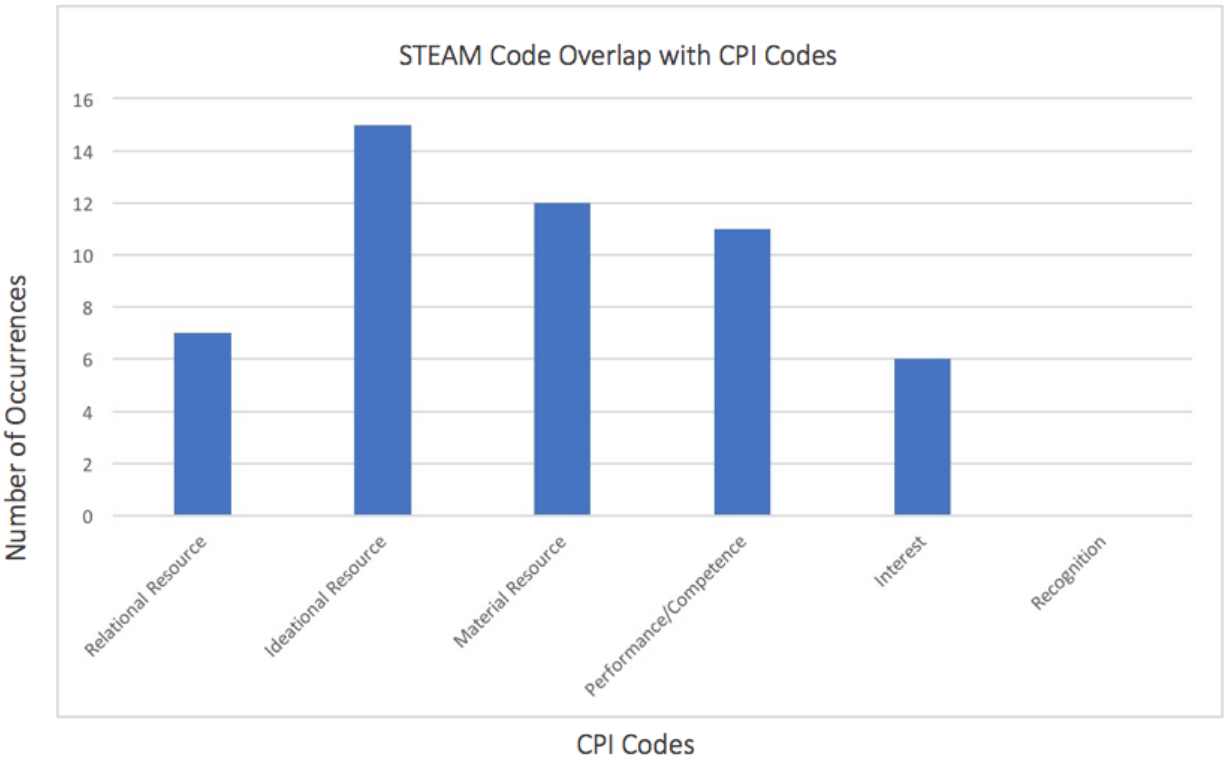

Figure 4.1: Graph of the Frequency of our Mother Codes in the CPI Framework that overlapped with the STEAM code.

There were fifteen occurrences where our ideational resource code overlapped with our STEAM code across five of our interviewee's. It was the resource that had the most overlap with our STEAM code. All the ideational subcodes were coded as internal, what's valued in physics, personal characteristics, positioning in physics and perception of physicist. In our subcode of what is valued in physics Subject 36 states:

"They share a lot of similar- for example for each you need a certain sense of an open mindedness and creativity to both, and imagination to visualize things, and kind of a will to explore. So I think each of them has kind of offered that same opportunity to create, in a way, or to learn, to explore the curiosity that I have about the world, and yourself really, because you're finding a connection with the world. You find a way to connect yourself to the universe and to the world around you. And in each of those I think they both, for me, had that spark for me."

From this we can infer that the performing arts are as valuable as that of physics. Additionally that the arts offer similar qualities to create, visualized and explore the connections of the world around them.

In our subcode of personal characteristics Subject 31 states:

"I think it makes it easier for me to hold onto a sense of identity, because if you're in a field where your identity is not present or it's not appreciated, you may not want to be that anymore. You may want to assimilate to something that other people are comfortable with. And me being in touch with what I speak about, or what other people are receptive to, when I speak, that kind of connects me to a sense of identity. That's how it guides me. Like I can do a job, I can do a task, I can be part of an occupation, but it doesn't have to define me."

The arts offered something that was very important to this person's sense of identity. This is a personal characteristic that this individual could differentiate between physics and the performing arts. The arts allow this person to be in touch with what she artistically can speak on that connects to their identity. In contrast to physics where their job or occupation is consistently connected to their identity, they find that the arts does not cater to being defined by the job they have, a task they perform or even their occupation.

There were twelve occurrences where our material resource code overlapped with our STEAM code across six of our interviewee's . We found that there was a wide range of

discussions of how the performing arts served as a material resource. For example Subject 11 states:

> *"I'm not sure whether it's the music specifically or just the way that you think– the way that you have to think about music is also the way that you have to think about doing science. I'm not, I don't know whether it's the art that supports you in becoming a physicist or whether it's a different manifestation of the way that your mind works."*

Subject 11 found that the way they thought about music was also very similar in the way they thought about physics. This is to say that physics and the performing arts have a unique intersection.

There were eleven occurrences where our performance/competence code overlapped with our STEAM code across four of our interviewee's. In our performance/competence code many individuals stated how they were able to be more analytical with other individuals, have the ability to be a well rounded person and how being active in a performance arts field helped them learn subjects more fluidly. Subject 10 gives us an example of how the arts can allow a person to be more creative:

> *"So I feel like if someone actually can bring in the arts side of things they can have much more creative ways of doing things than those who don't, and I don't think people generally associate fine arts with physics, so if someone could come in and really bring the two together it would be doing something both novel or unique and beneficial."*

They continue on to say that having strengths from the performing arts are valuable skills that can be used in physics.

> *"it's all about leveraging your strengths and understanding what your strengths are. If someone has that strength in one of the fine arts fields and they can bring that to physics that would be great."*

There were six occurrences where our interest code overlapped with our STEAM code across three of our interviewee's. Many of the individuals that had interest coded in their interviews mentioned that they did some type of performing arts during a period of their lifetime or just liked the performing arts as activities to do. For example Subject 28 states that they did participate in the performing arts while growing up but stopped when they went to college.

> *"I've been playing the violin since like third grade. Or I'm sorry, the piano since like third grade, and I picked up the violin in sixth grade. And it's something I tried to continue in college, but my undergraduate institution was just kind of one of those places where you have to pick something that you really want to focus on, and for me I wasn't trying to be a musician full time."*

Finally, we found that there were no recognition codes that overlapped with our STEAM code across any of our interviewee's interviews. This result was one of the most surprising results that we did not expect to come out of our data analysis. In our definition of recognition we understood that it meant "being recognized as a physicist or physics person." During our analysis and discussion we concluded that physicist that participate in the arts are not recognized as physicist within these performing arts fields.

4.0.2 Positive Sub-code outcomes

The graph attached shows the code counts of positive and negative mother codes in our CPI framework that overlapped with our STEAM code. Our performance/Competence code showed having the largest positive subcodes, six in total, in our mother codes that overlapped with STEAM. Interest and relational resource had the fewest positive codes, both having three each. Our material resource had five positive subcodes and one negative subcode.

In our relational resource we found that individuals who had formed positive relationships in the arts, could connect back to this person's physics identity. The codes that were coded as neither showed that these were just general interacts that they had in the arts.

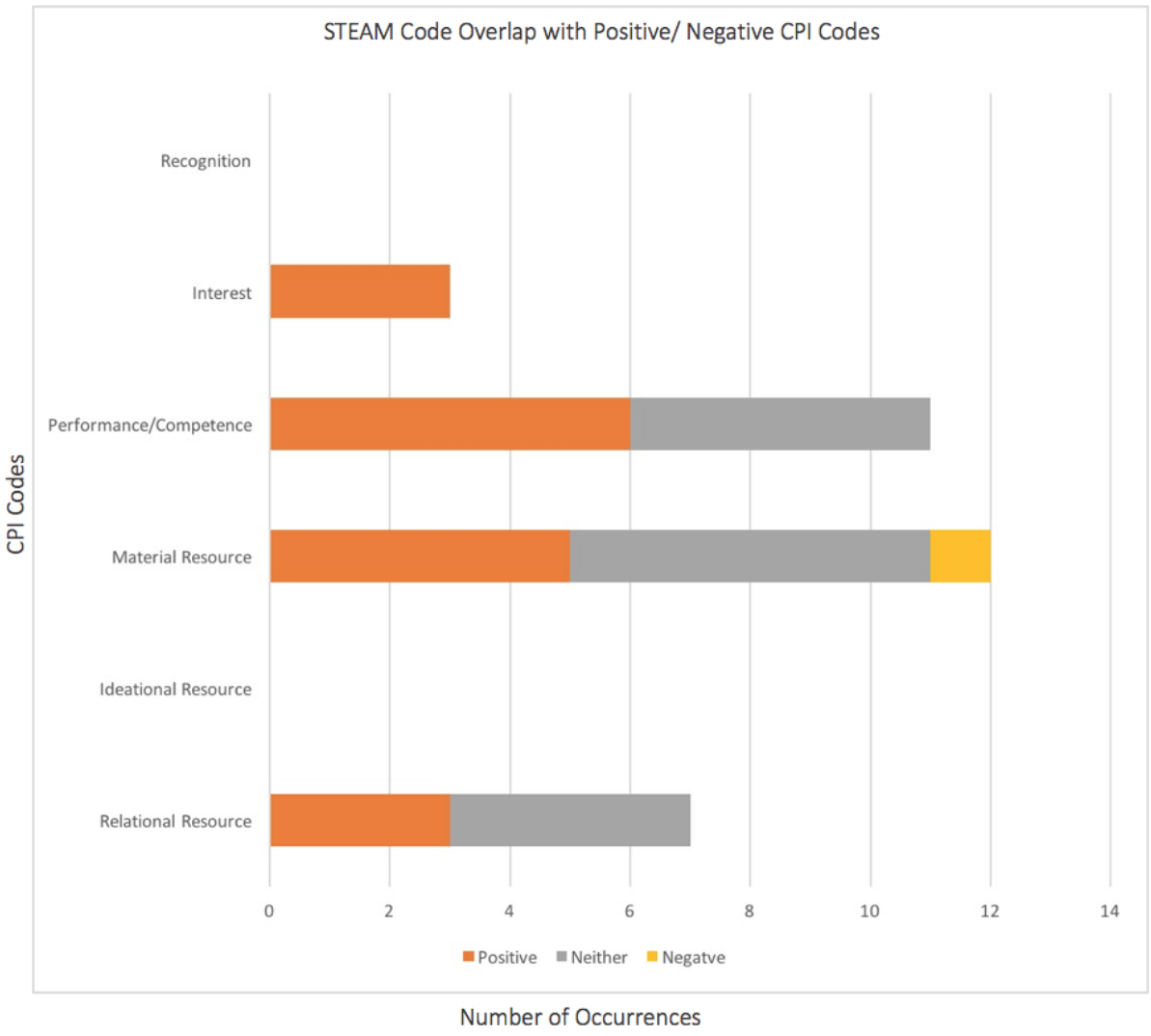

Figure 4.2: Graph of the CPI positive and negative codes.

After being prompted with the question of "Could you see yourself in the field of physics without having participated in the arts?" Subject 30 in turn responded:

"I don't think I would've had the confidence to do it to be completely honest. I don't think I would've been the person I am if I would've never participated in the arts. You know, me participating in the arts in middle school, high school, is what really opened me up to meeting more people."

By stating that participating in the arts opened them up to meeting new people, this indicated that the arts helped this individual to be confident when it came to forming

relationships in the physics community. Additionally, the areas where relational resource were coded as neither showed that though individuals form relationships in the arts that they do not connection back to their physics identity. Many times the individuals that they meet while involved with the performing arts rarely had any overlapping interest in the STEM fields and vice versa, until recently. Therefore it is understandable that these relationships that our interviewee's talked about have no net preference in physics. Subject 35 illustrates a perfect example of how relational resources do not connect back to a persons identity:

> *"I'm connecting with you on a whole other level than just business, or whole other level than just academics. Like I'm connecting with you in so many different ways that ultimately make this experience so much more meaningful, so much more worthwhile, so much more worthwhile. I feel like it's more likely for people to invest their time and energy into you when you can bring something else to the table."*

For the performance/competence code our positive subcodes showed a significant connection back to physics. For example Subject 36 states that they are able to think about physics in a creative way. They go on to say that knowing how inquisitive a person can be within the arts also allows a person to explore and ask question in physics. Below Subject 36 expand upon their arts identity creating positive physics abilities.

> *"I think because I have like a creative way of thinking about physics, or just the way- Just kind of the beauty in it, you know? I think because I see the beauty in it in a way that I see the beauty in art, it's kind of a motivating effect in a way, something that drives you to keep doing it or something. It feels like it's really kind of a part of your life, you know what I mean? As in you wouldn't really think of yourself ever not listening to music or not enjoying art. It's kind of the same way as I could never imagine myself not further wanting to explore, or driven to questions about understanding the universe, or further learning something more."*

For material resources anytime a person talked about the performance arts and the impact that it had on their life, it was coded as positive. Subject 33 talks about how they gained a sense of community and being able to relate to others. We can see this in an excerpt from Subject 33 used above where they said: "I think being involved in arts and I guess the spoken word things that I do sometimes, that just helps me relate to people. And it also gives me some direction."

There was one individual that had a negative material resource code in their interview. That was Subject 29. Though this person did use the arts as a material resource, they believed that this resource had absolutely no influence on their physics identity. They state:

"I loved music like since I was a little kid, and like doing music and podcasts and radio shows now it's like these separate worlds for me. Physics and music are two different worlds for me and it didn't influence the other one. Like me being in physics didn't influence me doing music more or getting into music more and vice versa."

From this we can gather that the arts sometimes do not have an influence on a persons physics identity. This particular person did not find it appealing to integrate the two. However this statement would not rule out the idea of the arts being a counterspace. They go on to say:

> *"Like for me personally I keep them separate because it's just, I don't bridge the gap between those because I think it's kind of cheesy when people blend like music and physics together, I think it's kind of cheesy. That's my personal take on it, I think it's kind of cheesy because like then you try to analyze the music too much and sometimes it's just like hey, enjoy it, like let it be what it is."*

They would rather love music for it just being music and love physics for just it being physics.

Overall, the performing arts positively impacts individuals who are involved in them. Secondly, what we can learn are that performing arts act as a material resource and stimulate personal characteristics about these Black physicist and also create relationships in the arts

and in physics. Lastly, in our sample no participant talked about receiving recognition as physicists from their participation in the performing arts however it does not mean that it isn't important or that others won't find ways to get it from the arts.

4.0.3 Code Connections

During our analysis process we saw the codes beginning to connect with one another during the interviewee's narratives. The first code connection that we saw was how a material resource, provide skills to support a person's performance/competence. The second code connection that we saw was how a material resource, is an avenue for relational resources.

This code connection tells us that people use the performing arts as material resources which leads them to personal ideational resources and support their performance and competence.

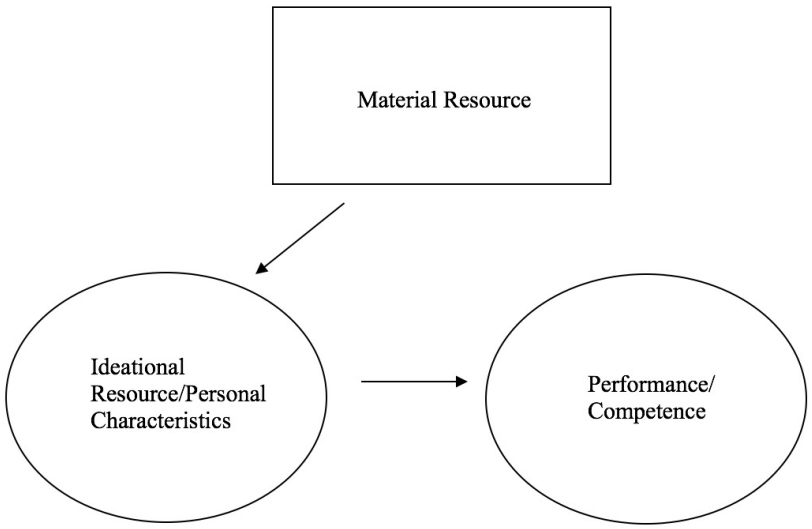

Figure 4.3: The first pattern that connects material resource, ideational resource and performance/competence.

For example Subject 31 states that they grew up participating in the performing arts, such as church plays. What they gained from participating in these performing arts activities was a sense of confidence, and oratory skills. They go on to iterate that physics never taught

them how to project and work with an audience. These mentions of confidence and skills are all personal characteristics that this individual found from doing the arts. Lastly, interviewee found that the two fields intertwine with one another and that the skills they learned in physics were used from the arts and that the skills learned in the arts were used in physics.

This code connection tells us that people use the performing arts as material resources which leads them to personal ideational resources and support their performance competence.

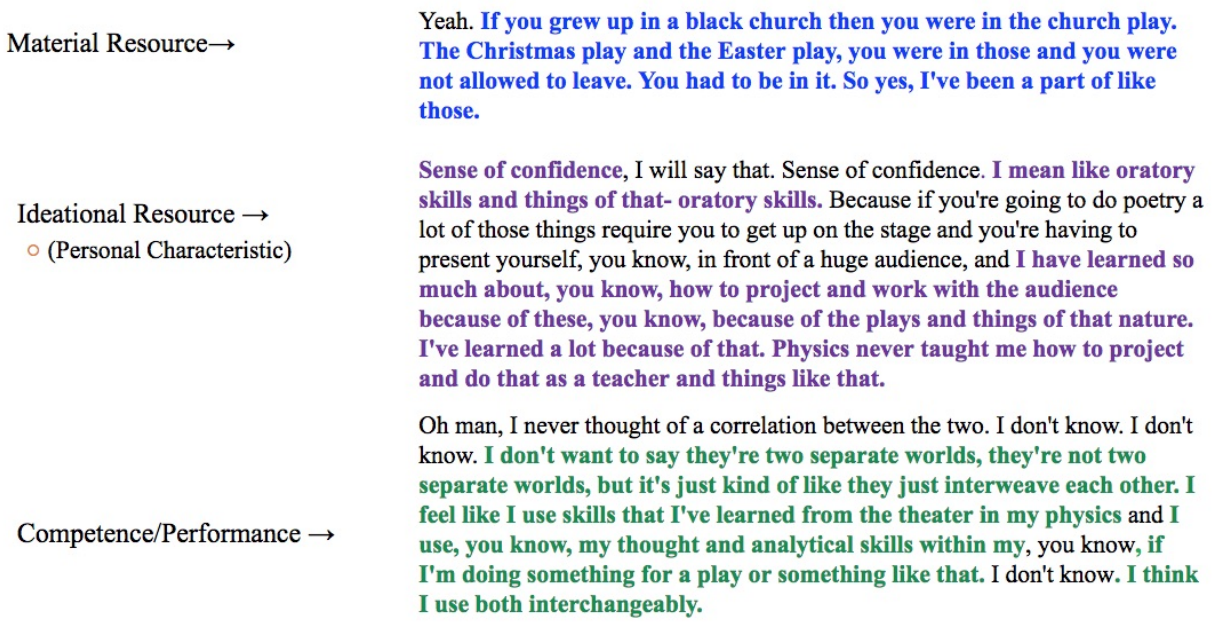

Figure 4.4: A coded example from Subject 31s interview of the code connection from Material resource, to ideational resource, to competence/performance.

The sections that are highlighted in this figure, point out the important points that encompasses each coded section.

Another code connection that we found in our analysis process was how material resources are avenues for relational resources to form.

This code tells us that these material resources again lead to internal ideational personal characteristics which then impacts the way they form relationships with other people. These relationships are often very positive when it comes to connecting with other people in physics or do not connect back to the physics community at all. For example Subject 11 states how they recently participated in a play. This opportunity came at a time when they were

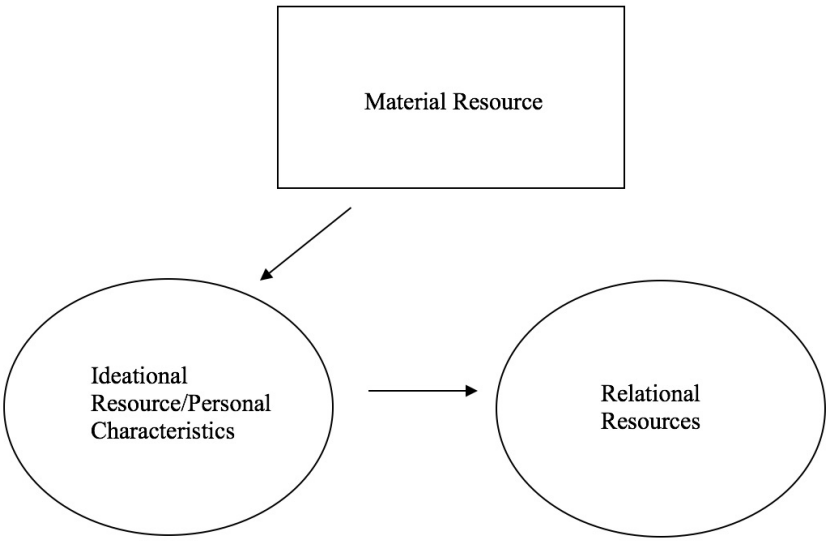

Figure 4.5: The second pattern that connects material resources, ideational resources and relational resources.

being recommended for tenure and also at a time where they couldn't turn this opportunity down. They knew that participating in this performing art aspect would challenge them and help them face their fears. Lastly knowing that this would be a challenge for them sparked personal characteristics within themselves. After seeing that these attributes connected with one another the interviewee found meaningful connections that could be incorporated back into their physics identity.

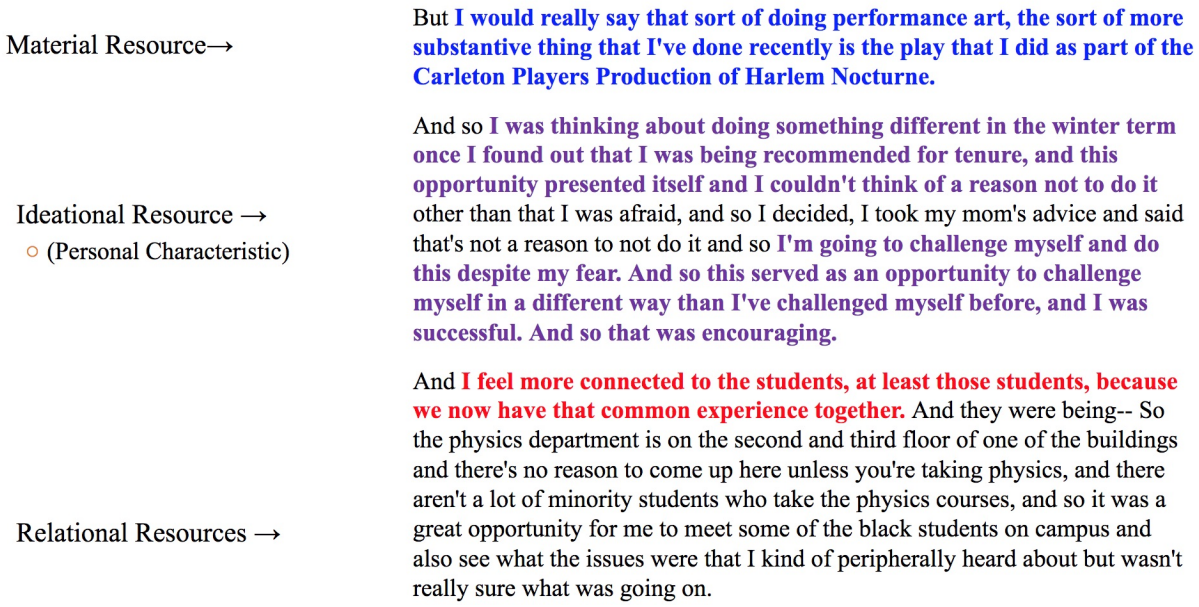

Figure 4.6: A coded example from Subject 11s interview of the code connection from Material resource, to ideational resource, to relational resource.

Chapter 5

Conclusion

The goal of this thesis was to address the research question of whether and how the performing arts support Black physicist identity. We used the CPI framework [11] and built out a STEAM identity framework to understand a Black persons physics identity within the performing arts. The frameworks showed us that participants did not discuss getting recognition as a physicist from participating in the performance art. However the frameworks showed us that the relational resource code, the ideational resource code, the material resource code, performance/competence code and interest code did overlap between physics and the arts. Our second finding in our analysis process showed that most of the codes used in the CPI framework had positive subcodes. Therefore suggesting that the performing arts have a positive impact on a Black person's physicist identity. Lastly, that there were code connections in the STEAM section that showed sequential patterns in an interviewee's narrative that elaborated on an experience or idea. They can include how the performing arts can act as a material resource that provide access to a person's physics identity which in turn can stimulate personal ideational characteristics about these Black physicist and also create relationships in the arts and in physics.

Understanding how the arts support Black physics identity has shown us how the performing arts can be used as a material resource like science programs or outreach. We found that they have positive impacts for ideational resources which create avenues for relational resources. Additionally, we found that these material resources are positive outlets for ideational resources that enhance a person's performance/competence. However the performing arts being that they are material resources do not always connect back to a Black persons physicist identity.

The use of the CPI framework and classifying the performing arts section of our interview as STEAM helped us to tell a different narrative of how the arts are supporting Black physicists rather than it being a tool to teach in the STEM fields. However we hope that in analyzing these interviews we find that it can be a guideline in designing informal programs in the future.

Additionally, seeing how the arts have supported Black physicists we hope that this work can be used to analyze and investigate other marginalized groups in physics as well. That is, that other groups will use this work as a stepping stone to learn if the arts can be a material resources and create avenues for relational resource and cultivate personal ideational characteristic to increase a person's performance and competence in physics.

Lastly, in our future work, we will continue finding Black physicists who want to share their stories on their involvements in the arts. With this in mind, this will help broaden our results, which will either solidify or challenge the code connections that we have presented here.

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