ABSTRACT

CHESNUT, LYNN CAMPBELL. How Do Science Museum Exhibits Contribute to Perceptions of Inclusion and Belonging? (Under the direction of Dr. K.C. Busch).

In the United States, museums offer an important opportunity for science education beyond the formal classroom. Museums, though, do not serve their communities equitably with only about 9% of visitors identifying as People of Color (POC). Prior research has concluded that perceptions of belonging are most responsible for this underrepresentation. This mixed methods study explored the relationship between perceptions of belonging and museum exhibits. The contribution this dissertation makes to the body of knowledge is an evidence-based analysis of the way that science is re/presented in science museums exhibits and how that contributes to perceptions of belonging which previously represented a gap in the research literature.

Using a phenomenological approach, data were collected from two sources: qualitative exhibit observations and a quantitative survey. Observations were made at area science museums and were analyzed using both inductive and deductive coding. Survey respondents were recruited from the community, and responses were analyzed using basic and inferential statistics. Three lenses were used to investigate the role of exhibits in belonging in science museums: critical theory, belonging theory, and a humanistic approach to science.

There were 4 major findings of this study. Science in museum exhibits is re/presented from a mostly dominant cultural perspective as unbiased canonical truth often separate from science process and human endeavor. In images, science is re/presented as a professional pursuit dominated by White males. POC survey respondents reported statistically significantly lower overall perceptions of belonging, but they were not able to attribute those perceptions to the way science is re/presented in exhibits (though White respondents were). These results suggest that

belonging in science museums is experienced inequitably by White and POC visitors and that the role of exhibits in perceptions of belonging is complicated. This research contributes to the goal of inclusive and equitable informal science for all by examining the potential sources of perceptions of belonging, specifically in the ways that science is re/presented in exhibit text and images.

How Do Science Museum Exhibits Contribute to Perceptions of Inclusion and Belonging?

by
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DEDICATION

To my family for their endless and unconditional help, support, and encouragement.

BIOGRAPHY

Lynn Campbell Chesnut was born in Wilmington, Delaware, but moved to North Carolina shortly thereafter where she grew up and attended Durham Public Schools. As a child, Lynn spent free time exploring the outdoors and using her imagination in play and creation. Other pursuits included Girl Scouts, playing French Horn in the school band, and earning participation awards in various sports. She graduated from Jordan High School where her real love of science began. She attended Davidson College and continued her studies in Biology. After college, an undergraduate biology degree meant work in various research labs, and this nudged her toward pursuing a post-graduate degree in science. She graduated from George Washington University with an MAT in Museum Education but ultimately landed in a position as a middle school science teacher in Durham. After almost 20 years of teaching, Lynn once again felt the call of graduate school. In 2018, she began her PhD in Science Education, and defended her dissertation in the Spring of 2024. She works at the Center for Public Engagement with Science, a part of UNC's Institute for the Environment, where she is dedicated to informal science education. She lives in Durham with her daughter Campbell, dog Pickle, cats Mikki and Vivi, and a backyard full of hens.

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CHAPTER 1: INTRODUCTION

Just turn on the news, and you'll appreciate the importance of understanding science for U.S. citizens. The public's engagement with science is critical for making sense of science in everyday life, such as daily weather, climate change, COVID-19 spread and vaccination, and the costs and benefits of alternative energy. We, as a society, depend on formal K-12 education to provide most of the learning opportunities for children, but once out of school, either for the day or for good, we look to other opportunities for science learning. Here is where informal science education institutions, like science museums, provide an important opportunity to continue science learning.

For more than 300 years, science centers and museums have provided important opportunities for learning (Rennie, 2021). When examined, the background literature on the structured learning environments of science museums suggests that they are an essential part of the science learning landscape along with formal school learning (Dawson, 2014) and can play a vital role in public engagement with science and science literacy (Feinstein & Meshoulam, 2014; Kim et al., 2022). Informal science education, though, is not being accessed equally.

Think back to the last time you were in a science museum. What was your experience? Was the place "made for you"? Did you feel a sense of belonging? For many people, visiting science museums is enjoyable. They feel comfortable and a part of what is going on around them. But for some, visiting a science museum is uncomfortable. They do not feel included, instead, they feel alienated and unwelcome. Researchers have explored the reasons why some people choose to visit science museums as a leisure activity, and they have found visitors are motivated by many different reasons, such as interest, knowledge, and entertainment but they are similar in the fact that they choose to spend their leisure time in museums.

Museum visitors, in the U.S., are similar in other ways: they tend to be White, middle-class, and well-educated (Collaboration for Ongoing Visitor Experience Studies, 2018). This overrepresentation of certain groups and underrepresentation of others has been well-documented for more than 30 years (Farrell & Medvedeva, 2010), and strategies to try to improve the diversity of visitors have been in place just as long (American Alliance of Museums, 1992). These strategies have tended to address perceived barriers such as cost (e.g., free or reduced admission), physical access (e.g., ramps, extended hours, transportation, etc.) and awareness (e.g., targeted advertising) (Garibay & Olson, 2020). Yet, the disparity in visitor demographics persists.

Researchers such as Garibay and Teasdale (2019) suggest it is time to stop viewing the problem as something that resides within the nonvisitor, barriers, like those mentioned above, that they must overcome and begin to recognize and address the issue as a problem within the institution. Furthermore, the aforementioned strategies also fail to address the root cause of the underlying inequities. The time has come for museums to embrace all potential visitors as having value and make systemic institutional changes that result in a welcoming and inclusive environment for all.

Several influential reports have concluded that a museum's visitors are often not reflective of their community (COVES, 2018; Farrel & Medvedeva, 2010). The work of Falk and others have described the many different motivations people have for visiting (Falk, 2016; Hood, 1993), and, recently, a few have examined the motivations people have for *not* visiting (Archer et al., 2016; Dawson, 2014). Research reveals that some groups, specifically people of color (POC), choose not to spend their leisure time in science museums, and the principal reason is perceptions of discomfort, a sense of exclusion, and a lack of a sense of belonging (Farrell &

Medvedeva, 2010; Falk, 2016). This noted nonparticipation is important because it implies that science museums are not serving their communities equitably (Archer et al., 2016; Dawson, 2014).

Like all museums, science museums attempt to present and represent their subject matter—science—in a way that they *think* is unbiased, neutral, and relevant to their visitors (Alexander et al., 2017; Sandell, 2003). A logical place to begin to understand the disparity in visitor diversity is with the two main ways science museums offer science to their visitors: programming (such as tours, classes, and lectures) and exhibits (Bitgood, 1992). Because "museums are not museums without exhibitions" (McLean, 1999, p. 1), this dissertation research examines how exhibits, specifically, may contribute to perceptions of belonging and inclusion in science museums. In this study, the promise of a humanistic approach—one that re/presents science as a process of human endeavor—is offered as one way to improve feelings of belonging.

Two theoretical frameworks that probe the relationship between inclusion, belonging, and informal science are employed to guide the approach to this research—Critical Theory and Belongingness Theory. Critical Theory is concerned with "exposing, disrupting, or changing institutional arrangements in society…by engaging with issues of domination, oppression, and/or inequality" (Lok, 2019, p. 339). Belonging is social phenomenon and an essential human motivation to be valued and accepted (Baumeister & Leary, 1995). These frameworks are important in that they enable the exploration of control and power in the museum context *and* the role of comfort and value in the visitor.

Relevance and Importance of the Research

Many research studies have explored science learning (Lederman et al., 2023). While most were conducted in K-12 formal educational contexts, some of these studies took place in informal settings such as science museums (e.g., Falk & Storksdieck, 2010; Hauan & Kolsto, 2014; Ramey-Gassert et al., 1994). Science museums can provide a learning environment for all, yet currently they do not serve their communities equitably. If science museums are able to transform the way they are re/presenting science, in a way that is culturally relevant, welcoming, and equitable for their community, they could truly fulfill their mission of *science for all* (Project 2061, 1989). This research contributes to that goal by examining the potential sources of perceptions of belonging, specifically in the ways that science is re/presented in exhibit text and images.

Research Problem and Questions

Museum demographics clearly illustrate that the studied visitors are not reflective of the diversity of the U.S. population (Farrell and Medvedeva, 2010; COVES, 2018). To best serve their current *and* potential visitors, museums must address the reasons why groups of people do or do not visit. One possible reason may be feelings of exclusion or lack of belonging.

This study intends to develop a better understanding of the perceptions of inclusion and belonging in informal science learning environments (science centers and museums) from the perspectives of both the institution (through exhibit observations) and the visitor (through survey). The aim of this study is to identify the ways in which science is presented and represented in science museums, and how this re/presentation affects perceptions of belonging and inclusion among visitors. The research questions this study addresses are:

- RQ1: How is science re/presented in science museums?

    - In exhibit text?
    - In exhibit images of people?
- RQ2: How does the way science is re/presented contribute to perceptions of belonging and inclusion for visitors (current and potential) of science museums?

Terminology

Throughout this study, the focus is on the topics of informal science education and inclusion and belonging. Therefore, it is important to clarify how these and other concepts are defined and used. The following definitions are not meant to be "truth" but instead are included to provide clarity and consistency.

Formal, informal, and nonformal science education have been defined in many ways by many researchers. The Center for the Advancement of Informal Science Education (CAISE) defines informal STEM education as "lifelong learning in science, technology, engineering, and math (STEM) that takes place across a multitude of designed settings and experiences outside of the formal classroom" (CAISE, n.d., para. 1). In *Learning Science in Informal Environments: People, Places, and Pursuits* informal science is defined similarly as science learning that happens "beyond the schoolhouse door" in many different informal environments (e.g., libraries, museums, discussions at home) (National Research Council, 2009, p. 1). In this dissertation, the term *informal science education* (ISE) is used to describe science learning that takes place in a structured setting outside of school, *formal science education* describes science learning that takes place during the school day (i.e., science class), and *non-formal science education* describes science learning that occurs in an unstructured setting such as free-choice backyard exploration.

Informal science education (ISE) takes place in designed environments such as science centers and museums but also in afterschool clubs, camps, and other structured settings (National Research Council, 2009). This paper will focus on ISE that takes place in designed *informal science learning environments* (ISLEs) such as science museums. *Museum* refers to any "designed informal learning environment" which includes science centers, science museums, natural history museums, zoos and aquariums, and botanical gardens (Gutwill, 2016, p. 206).

The users of ISLEs are referred to as *visitors* or *participants*, and those who do not use them as *nonparticipants* or *nonvisitors* (whether or not by choice). When the word *community* is used, it can refer to both the area physically surrounding the ISLE and the culture of the people living there (which may include race, ethnicity, language, and current and historical experience) (Applebaum and Price, 2020). *Broadening participation* is characterized as "increasing participation of people from historically underrepresented communities in the pursuit of STEM studies, professions, and civic decision-making" (Bevan et al., 2019, p. 2). *Belonging* is defined as feeling like a valued, accepted, and legitimate member in a community (Lewis et al., 2016). Belonging differs from inclusion in that it implies being included *and* valued (AAM, 2019). Though imperfect, the American Alliance of Museums (AAM) definitions were used for *inclusion*, *diversity*, *equity*, and *accessibility* (AAM, n.d., para. 3-13):

- *Inclusion* refers to the intentional, ongoing effort to ensure that diverse individuals fully participate in all aspects of organizational work.
- *Diversity* is all the ways people are different and the same at the individual and group levels.
- *Equity* is the fair and just treatment of all members of a community.

- *Accessibility* is giving equitable access to everyone along the continuum of human ability and experience.

In this dissertation, the phrases *re/present* and *re/presentation* are used to convey at once the idea of science presentation and *re*presentation in exhibit spaces. Science *presentation* refers to different epistemic perspectives, ways of knowing, including *science as unbiased and factual truth* and *science as biased human endeavor* (Wade-Jaimes& Schwartz, 2019; Oliveira et al., 2012). Science *representation* refers to different historical and cultural perspectives including a dominant White Western approach and a more multicultural diverse approach (Steinke, 2005; Quinlan, 2021; Carlone & Johnson, 2007). Science representation also includes who creates, gets credit for, and controls knowledge. Both science presentation and representation are concerned with validity and reliability of science knowledge.

Overview of the Dissertation Research

This dissertation employed a mixed methods phenomenological approach. A phenomenological approach, the most appropriate approach for describing lived experience, was used to explore what people experience and how regarding belonging and inclusion in museums (Creswell and Poth, 2018). Exploratory sequential mixed methods were used to integrate quantitative and qualitative data sources providing a more thorough understanding than either source on its own (Creswell & Creswell, 2017).

To answer research question 1, qualitative methods were used to examine how science is re/presented in science museum exhibit text and images of people. Data consisted of directly observing exhibit text and images of people from 6 science exhibits at three museums. This data was coded both inductively and deductively.

To answer research question 2, quantitative survey methods were used to measure how the way science is re/presented contributes to perceptions of belonging and inclusion for current and potential science museum visitors. The results from the qualitative data analysis were employed to construct the survey's A/B messaging items and then used to measure perceptions of belonging. Data consisted of responses to a 34-item survey collected from 61 community members. The survey data was analyzed with inferential and descriptive statistics.

CHAPTER 2: LITERATURE REVIEW

Introduction: Unchanging Museums for a Changing Audience

A report published in 2010 by the Center for the Future of Museums called attention to the changing demographics of the U.S., moving from a racial/ethnic minority (majority is defined as non-Hispanic White) population of 10-13% prior to the 1970s to 34% in 2010 (Ferrell & Medvedeva, 2010). In 2020, census results reported a minority population greater than 40%. The center's report also describes 2010's core museum visitorship as only 9% minority (Figure 2.1). In 1993, Marilyn Hood chastised the museum community for ignoring the literature on visitor research and evaluation that goes back to the turn of the 20th century (Hood, 1993). Since Hood's admonishment, museum visitor research results still tend to focus on and cater to the frequent visitor (Goulding, 2000; Pierdicca et al., 2019; Liu & Idris, 2018), who even now,

Figure 2.1

Population Trends and Museum Visitors (Farrell and Medvedeva, 2010, p. 5).

despite the changing demographics of the US population, looks very much like they did more than 100 years ago.

To respond to this underrepresentation, it is crucial that museums scrutinize not only the motivations of the nonvisitor and devise strategies to attract and retain them but also the purpose and historical motivations of the museum institution itself. If not, they may not survive. This chapter will present literature on the role of the museum, including exhibits and the demographics and motivations of visitors and nonvisitors. Two frameworks are described that are used to examine both the museum and the visitor—Critical Theory and Belongingness.

The Problem with/in Museums

The Changing Role of the Science Museum

For more than 300 years, science centers and museums have been an essential part of the informal science landscape by providing critical structured science learning environments (Rennie, 2021), but not for all and not equitably (Archer et al., 2016; Dawson, 2014). The earliest science museums evolved from "cabinets of curiosity," collections that were full of scientific oddities from around the world (biological, geological, and archaeological) but also contained religious and cultural artifacts (Giannini & Bowen, 2019; Nelson, 2015). Iannini and Pedretti (2020) categorized these precursors of the natural history museum as First Generation Science Museums focused on acquisition and display (See Table 2.1). Upon the collector's death, these assemblages were often donated to universities for research and conservation (Niittynen, 2023). One had to be of sufficient socioeconomic status to acquire and maintain the objects, so not everyone could participate (Nordin, 2013). Therefore, these early museums were exclusive and presented and perpetuated their creators' elite dominant cultural perspective. Their purposes were conservation, collection, research, and training (Friedman, 2010).

The turn of the 20th century marked the transition in the role of the science museum from the display of objects to an institution of scientific knowledge (Iannini & Pedretti, 2020). Iannini and Pedretti (2020) classified the latter as Second Generation Science Museums (See Table 2.1). In Table 2.1, museum inclusion and equity efforts are mapped to Iannini and Pedretti's (2020) "Generations of Science Museums" and exhibit typology.

While research remained an essential purpose for many museums, education became as, if not more, essential (Iannini & Pedretti, 2020). Museums had become ostensibly public institutions offering not only collections but also lectures and other programming. While the purpose of the museum had shifted to education, it remained very didactic, with objects that were not meant to be touched and exhibits containing a lot of informational text (Nelson, 2015).

In the early 1960s, the science museum's role began to evolve again. The U.S. became home to many interactive science centers with experiential, hands-on exhibits (Iannini & Pedretti, 2020). These Third Generation Museums also began to recognize that their visitors were not very diverse and set about to remove perceived barriers to participation, such as cost, location, and hours (Garibay & Teasdale, 2019). In essence, museums wished to *fix* the deficit in the visitor, and no real effort was expended toward structural change in the museum itself (Garibay & Teasdale, 2019).

By the 1990s, museums had better understood diversity issues. There were efforts to diversify staff and boards of directors and to make connections to their community (BoardSource, 2017; Karp et al., 1992). It has been only recently, though, that museums have recognized that the "problem" of diversity, equity, and inclusion predominantly resides with the

Table 2.1

Evolving Museum Model.

Museum Inclusion/Equity	Science Museum Generation[1]	Exhibit Type
Museums exist to serve those who build them, current visitors, and the elite; no interest in attracting/keeping new/diverse visitors	First Generation (19th century): curiosity cabinets; display private collections of oddities; science museums were institutions of authoritative, uncontestable knowledge	Display
Museums recognize lack of diversity so lower/remove barriers so that visitors can overcome their deficits (time, money, transportation); or museums implement "outreach" to enlighten/educate/elevate ("bring you up to where we are"); no structural change to the museum itself; places the "problem" with the visitor	Second Generation (1900-1960s): a shift in the goals of science museums that moved from display of objects (specimens from collections) to the re/presentation of scientific ideas and concepts; educational function of museums became prominent while research retreated to behind the scenes	Pedagogical
Museums begin to recognize that removing barriers does not completely solve diversity problem; begin to examine systemic structures; beginning to implement strategies, recognize knowledge/value of the community; reposition relevance; beginning to place "problem" with institution	Third Generation (1960s-present) Move away from the object-based approaches; primary goal is to present scientific ideas and concepts through interactive and hands-on exhibits; strong emphasis on education and enhancing public understanding; science museums become science centers	Experiential

Table 2.1 (continued).

	Fourth Generation (present-future): Central commitment to more progressive views of scientific literacy, with a view to promoting responsible citizenship, critique, and action	**Critical and agential Relevant/asset-based**

1 Pedretti & Iannini, 2020b

institution rather than within their visitors (Garibay & Teasdale, 2019). Currently, some science museums, categorized by Iannini and Pedretti (2020) as Fourth Generation Science Museums, have begun to commit to "more progressive views of scientific literacy" through agential and critical exhibit types which engage visitors in socially impactful action (Iannini & Pedretti, 2020, p. 705).

The Role of Exhibits

As museums changed over time, the existing literature on exhibits in science museums has also evolved. Many early studies focused on content-based learning outcomes, but over time research focused more and more on the observable behaviors of visitors, such as engagement, in exhibit spaces. Csikszentmihalyi and Hermanson (1995) characterized the importance of engagement in the construction of knowledge, and Borun et al. (1996) found a strong relationship between learning and observed behaviors. Most of this behavior-based research clearly demonstrated that the ISLE "nurtures curiosity, improves motivation and attitudes toward science, engages the visitor through participation…, and generates excitement and enthusiasm" (Bariault & Pearson, 2010, p. 91). With the evolution of more experiential exhibits, many studies assessed the effectiveness of interactive exhibits and found interaction increases engagement (e.g., Barriault & Rennie, 2019; Vom Lehn & Heath, 2005). Active learning methods in exhibits can also play a role in science museums' public's engagement with science concepts and scientific research and encourage social interaction (Dilmen & Kirci, 2022; Perez-Bermejo et al., 2021; Vom Lehn & Heath., 2005). Active learning in exhibits can help promote science practices such as hypothesizing, data collection, and analysis (Dilmen & Kirci, 2022).

Bariault and Pearson (2010) developed their Visitor Engagement Framework (VEF) to capture and quantify engagement with exhibits as a measure of learning. This observation tool was used in the museum environment and required the observation of both behaviors and conversation. The highest level of engagement was evident in breakthrough behaviors including seeking and sharing information and referring to past experiences. Examples were provided that showed how an exhibit's VEF profile could be used to modify exhibits, but modifications were limited mostly to reorganization of components and clarifying instruction labels.

More recently, research literature has explored the use of exhibits to engage a greater *variety* of visitors, including underrepresented groups (Allen, 2004). Exhibits that connect to visitors' prior knowledge and are personally relevant have been found to provide the greatest opportunities for learning (e.g., Falk & Storksdieck, 2005). Interactive exhibits have also been shown to equally engage both genders and a variety of age groups (Greenfield, 1995). Exhibits can be used to engage visitors in controversial and socially relevant topics (Rennie, 2021; Pedretti & Iannini, 2020a). Exhibits that present varying levels of complexity allow visitors of differing abilities and knowledge to benefit from the experience (Arce-Nazario, 2016). While much of the described research explored learning with their current audience, some museums have begun to understand that it is crucial to think about exhibits and the needs and motivations of the nonvisitor (Allen, 2004). Meisner et al. (2007) shared that science museums were important in shaping visitors' attitudes toward science. A museum's exhibits play an important role in helping to promote belonging, inclusion, and diversity by addressing the needs of different types of people, especially those traditionally underrepresented in science (Feinstein & Meshoulam, 2014). Still, museums use exhibits to present their particular view of science, potentially alienating those same visitors they're hoping to draw in (Hine & Medvecky, 2015; Henriksen & Frøyland, 2000).

Science Textbooks: An Analogous Model

In a manner similar to museum exhibits, science textbooks re/present their subject matter in a variety of ways. Research has focused on examining the nature of science, specifically science as a body of knowledge (canonical knowledge), a way of thinking (the way scientists work), and as a process for investigating (a way for students to find out), but also how scientists are represented. One study of life science textbooks found that the textbooks most often presented science as a body of knowledge and a process for investigating but not as a way of thinking (Chiappetta et al.,1993). Another study with biology textbooks found the presentation of science as mostly canonical knowledge and found that discussions of science process and thinking was often neglected or misleading (Irez, 2009). These results were further confirmed by a more recent study of middle school textbooks (Agustin, 2021). A study of diagram and images in science textbooks found that image representations of scientist were mostly male (Akcay et al., 2020). Like museum exhibits, science textbooks can play an important role through their representations in the way their users characterize and conceptualize science. And, like museums, science textbooks tend to represent science as mostly canonical knowledge.

Critical Theory

This dissertation uses a critical lens to examine the efforts of museums to improve inclusion and belonging and reduce exclusion and alienation. Within the museum, there are clear imbalances of power and inequity between the institution and the visitor (Farrell & Medvedeva, 2010). Traditionally, the museum decides what to display, how to display it, and who interprets and is meant to consume the content (Blackwood & Purcell, 2014). Within the museum, exhibits can play a considerable role in expressing and asserting the institution's cultural and historical narrative and authority (Blackwood & Purcell, 2014). Because this study addresses issues of power distribution and equity, a critical theory framework is most appropriate (Creswell & Poth, 2018).

Origins of Critical Theory

Modern Critical Theory grew out of the work of the Frankfurt School (principally Horkheimer and Adorno) and later Jürgen Habermas whose take was less philosophical and more pragmatic (Ray, 2004). Critical theory is focused on acknowledging, exposing, and confronting the power structures that exist in society. In this study, I use Horkheimer's definition to explain the appropriateness of critical theory for this topic. Horkheimer defined a critical theory (Bohman, 2003) as:

> A critical theory is adequate only if it meets three criteria: it must be explanatory, practical, and normative, all at the same time. That is, it must 1) explain what is wrong with current social reality, 2) identify the actors to change it, and 3) provide both clear norms for criticism and achievable practical goals for social transformation. (numbering added for clarity, pp. 1-2)

Consistent with Horkheimer's definition, this dissertation is attempting to explain the current problem with museums which is that 1) they are exclusionary and tend to provide a dominant re/presentation of science. The actors identified to change this are 2) the institutions themselves (not the visitors) because visitors have little power over practices at established institutions. The norms identified for criticism here are 3) the current practices in science museums which include hiring and employment, boards and leadership, programming, and exhibits. This dissertation will focus on exhibits and specific goals to transform them.

Critical Theory and Museums

The use of Critical Theory in examining museums has led to a reevaluation of their purpose and roles, the exploration of diverse perspectives, and their democratization (Runnel & Pruulmann-Vengerfeldt, 2014). Little of this critical work, though, has been done science museums. Critical theories have often been used in museums to question narratives and shine a light on diverse perspectives (Valtysson, 2022). Some scholars have pushed for a reorganization of both practice and theory in museums by using a critical lens (Jeffery, 2021). This reorganization has resulted in the creation of a "critical museum theory" that is influenced by critical theorists and conceptualizes socially relevant museum practices (Rowe, 2018). This new framework has been crucial in challenging authoritative perspectives and narratives and advocating for those less dominant and more diverse (Jeffery, 2021). This new view marks a shift toward more relevant experiences for community members (Rowe, 2018; Valtysson et al., 2021). Critical theory in museums has allowed the questioning of dominant histories and collections and put them in a position to aid communities in social disruption and change (Munro, 2013; Roussell et al., 2020). While critical theory has been used to successfully examine re/presentation in historical and artistic museums, it is also beginning to be used to dismantle dominant perspectives in science museums, for example being used in developing queer tours of science and technology museums (Armstrong, 2022). It may be easier to identify the dominant narratives in the more human-centered narratives of history and art museums, critical theory can also be used to examine science narratives for science is a human endeavor.

The Museum Visitor and Motivation

Who Goes and Why?

Demographic data tell us about the typical museum visitor: White, straight, college-educated, and financially comfortable (COVES, 2018). In the U.S, the Association for Science and Technology Centers (ASTC) reports that their 600+ member organizations attract more than 110 million visitors annually (ASTC, n.d.), and the COVES Project (2018) published in 2018 reported on the demographics of those many science museum visitors. Sixty percent of visitors identify as female, and 60% are between the ages of 25 and 44. Most visitors (55%) were in local-only groups, and groups were most often composed of 2 adults (50%) with 1-2 children (59%). Most visitors reported no temporary or permanent disability (89%). Most were White (65%), straight (87%), moderate to high SES (60% over $50,000), and college educated (68%).

In addition to the collection of demographic data on visitors, many studies examine the motivations of those visitors—why they chose to spend their leisure time in a museum. Hood (1989) found that frequent museum visitors particularly valued opportunities to learn, the challenge of new experiences, and doing something worthwhile. John Falk (2009) developed a framework for describing and categorizing visitors' identity types depending on their motivation for visiting which ranged from recharging and seeking an experience to learning more about a specific topic (explorer, facilitator, experience seeker, professional/hobbyist, and recharger). Additionally, he revealed that the number one factor in choosing to visit a museum (or not), for both Black and White people, was "feeling comfortable and at ease in one's surroundings" (Falk, 1993, p. 49). Similar to Hood, COVES (2018) reported that the most common motivations for visitation were to spend time with a group or family, to provide fun/entertainment for group or self, as an educational experience for group, and as something to do while visiting an area.

Who Doesn't and Why Not?

Not surprisingly, most studies of museum visitation focus on the people who make it through the door and not on those who've chosen to stay away. The demographics reported above signify that males, young adults (under 25), non-family groups, disabled people, non-college-educated people, People of Color (POC), LGBTQ+ people, and people of low SES are underrepresented as science museum visitors. These demographic data on museum nonvisitors emerge as the opposite of the demographics of museum visitors.

While the demographics of the typical nonvisitor may the opposite of the typical visitor, the same cannot be said of their motivations. Few studies have explored the reasons people *don't* visit science museums. Hood, whose studies have centered on why people do or do not visit museums, reported that "people choose to come to museums, to find experiences that reward their investment of time, effort, attention, and sometimes money…[a]nd they choose not to come if they find the rewards don't meet their expectations or are less than they can attain in alternative offerings" (Hood, 1993, p. 19).

Hood (1989) found that nonvisitors valued different leisure time attributes than frequent visitors, particularly being with people, feeling comfortable and at ease, and participating actively; attributes they felt they couldn't find at museums. When Falk (1993) repeated Hood's approach he found that the nonvisitors he surveyed valued similar attributes: being with people., feeling comfortable and at ease, and doing something worthwhile. In the same study, Falk found that the largest discrepancy between Black and White respondents was museum habitus, a pattern of museum-going in childhood, while "latent racism and socioeconomic disparities" also accounted for differences in museum visitation (Falk, 2009, p. 50). Archer et al. (2016) found that disadvantaged families found science museum visits both "disorientating" and "fun," and their experiences most influenced by habitus and capital, defined as knowledge, attitudes, and experiences built throughout one's life. In Dawson's UK case study of groups marginalized in ISE, she found that ISE opportunities are "marked by structural inequalities that mirror and reproduce social advantages and disadvantages" (Dawson, 2019, p. 1). Dawson also developed a framework for ISE inclusion that includes Infrastructure Access (resources and capital), Literacies (language and "know-how"), and Community Acceptance (letting outsiders in) (Dawson, 2014). Where there is overlap between the leisure motivations of visitors and nonvisitors (e.g., spending time with family/friends or feeling at ease), museum visitors find their needs satisfied at the museum, and nonvisitors believe they won't find their needs satisfied at the museum or that they'll find a more satisfying experience elsewhere.

Belonging Theory

Because Falk's (2009) work found that the number one factor in choosing to visit a museum (or not), for both Black and White people, was comfort and feeling at ease, a lens that explores those perceptions is appropriate. Belongingness attempts to identify the cues that contribute to feeling accepted and valued and is therefore an appropriate framework.

What is belonging?

A sense of belonging, feeling like an accepted and valued part of a place or group, is so fundamental that Maslow placed this need only above physiological needs (food, water, etc.) and safety (Maslow, 1958). Leary and Cox argued that the "need for acceptance and belonging (or belongingness motivation) is a fundamental social motive that underlies and helps to explain a great deal of human behavior so basic…that [it underlies]...virtually every theory of social or cultural behavior" (Leary & Cox, 2008, p. 27). The Theory of Belonging focuses on "the perceived fit between the self and a context," in this case the visitor and the museum (Walton & Brady, 2017, abstract). Baumeister and Leary (1995) contend that feelings of belonging arise from cues in the environment to help people form relationships and a safe of belonging, and if those cues are not present in one context, individuals will seek a sense of belonging somewhere else.

Educational researchers have identified key features of belonging. Goodenow and Grady (1993) cited feeling accepted, respected, and valued as most important in feeling a sense of belonging, while Allen (2020) cited the need for constant, positive, personal interactions with other people and a stable continued bond and mutual concern to feel belonging. Still others have cited important aspects such as feelings of empowerment and amplification (Faircloth, 2021; Gray et al., 2020). In the museum context, repeat visitors are ostensibly finding their need for belonging met, while non-repeat visitors and nonvisitors didn't or believe they won't find sufficient belonging cues and choose to spend their leisure time elsewhere.

Belonging and Museums

A sense of belonging has been studied in many contexts including the workplace (e.g., Canlas & Williams, 2022) and schools (e.g., Osterman, 2000) and instruments have been created to measure belongingness in those contexts (Lee & Robbins, 1995; Akar-Vural & Yilmaz, 2013). The results of studies using those instruments have yielded overwhelming evidence that belonging is a critical aspect of success and perceptions of acceptance and inclusion. In 2019, the

Centers for Disease Control and Prevention added belonging as a recommendation for maintaining healthy schools (Allen, 2020).

Prior to 2022, despite an acknowledgement (from within the museum community and from without) that museums were failing to attract diverse audiences (Feinstein, 2017; Black, 2016), and that, like other contexts, belonging plays a large part in the lack of diverse participation (Falk & Dierking, 2016), no attempt had been made to develop a scale for belonging in museums. In 2022, Price and Applebaum developed a survey instrument that measures belonging in museums (2022). They found that visitors who identified as White reported higher levels of Community belonging, while visitors who identified as Black reported lower levels of Place belongingness. They also found that Black visitors tended to define community related to their race/ethnicity and White visitors as place or location. The instrument was originally tested with visitors leaving a science museum (Price & Applebaum, 2022) and was further tested with visitors at a variety of cultural institutions (L. Applebaum, personal communication, October 7, 2023). The instrument has not, however, been tested with nonvisitors, the group most likely to report an absence of belonging in the museum.

In science museums specifically, research has focused on social inclusion and exclusion (not so much perceptions of belonging). Much research on inclusion has focused on the diversity of staff and other museum personnel, yet some studies have examined inclusion of the visitor (Weiland, 2015; Tlili, 2008). Dawson (2014) found that science museums can exclude low-income and minority ethnic groups who often feel disconnected. Skydsgaard et al. (2016) found that scientific jargon can increase alienation while using narratives can increase inclusion by making content more relevant and memorable. Mobile science museums have helped to increase inclusion especially for those underserved (de Souza Gonzalez et al., 2021). So, while progress has been made in improving inclusion in science museums for some, the demographics of visitors remains mostly unchanged (Feinstein & Meshoulam, 2014).

Summary

In summary, if U.S. museums wish to survive the changing demographics of the population, they must respond to the primary need of visitors and nonvisitors alike—a need to belong. There are two ways to approach the issue of disparity in science museum visitorship. One way can be to view the problem as residing within the institution itself. Museums and their exhibits tend to offer a more traditional dominant re/presentation of science. A critical lens can be used to examine those re/presentations along with the power dynamics that create them. Another way can be to view the problem as residing within the person. In this case, people face barriers that prevent them from taking part in museums, the greatest of which is a sense of belonging. Belongingness theory can be used to explore factors within the museum that contribute to a sense of belonging.

CHAPTER 3: METHODS

Introduction and Research Questions

The purpose of this study is to develop a better understanding of perceptions of inclusion and belonging in informal science learning environments (science centers and museums) from the perspectives of both the institution and the community. The "community" is represented by community members who are both regular museumgoers (visitors) and nonregular museumgoers (1 or fewer visits per year) henceforth referred to as non-visitors. The research questions this study addresses are:

RQ1: How is science (re)presented in science museums?

- In exhibit text?
- In exhibit images of people?

RQ2: How does the way science is re/presented in science museums contribute to perceptions of belonging and inclusion?

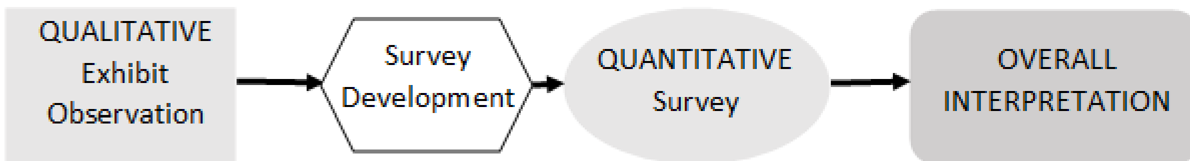
This chapter presents a description of the chosen mixed methods approach followed by the research design including the context, participants, and data collection and analysis. Because this research involves data that may be considered sensitive and participants who may feel marginalized and vulnerable, the ethical considerations of the study are considered here as well.

Research Approach

This study used mixed methods with a phenomenological qualitative approach supported by quantitative pilot survey data. A mixed methods approach was chosen because it allows for the integration of quantitative and qualitative data sources which provides more complete understanding of the research problem beyond that supplied by either source alone. The specific approach is an exploratory sequential mixed method (Figure 3.1). In this approach, the researcher first collects qualitative data which is analyzed and used to construct the second quantitative phase (Creswell & Creswell, 2018). In this study, I collected observation data from museum exhibits which were analyzed to create a survey based on themes developed during the qualitative phase.

Figure 3.1

Study Methodological Design.



Phenomenology

The focus of this study is the experience of belonging, equity, and inclusion for science museum visitors, particularly in underrepresented groups. Therefore, the specific approach chosen is phenomenology, which is most appropriate when examining what and how people experience a lived experience and develop a deeper understanding of it (Creswell & Poth, 2018). To investigate this phenomenon, data for this study were collected from multiple sources (observations and surveys). It is hoped that the study's findings will inform both practice and policy around equity-building in science museums.

Of the two types of phenomenology, this study's methods most closely match Moustakas's (1994) transcendental or psychological phenomenology in that it focuses more on the description of the experience and less on interpretation as found in van Manen's hermeneutic phenomenology (1990). Moustakas's more structured approach also better supports the needs of this novice researcher. The process begins with choosing any phenomenon people experience (e.g., adoption, pet death, anxiety, or housekeeping). Next, data is collected from individuals (usually a group of 4-15) who have experienced that particular phenomenon. Data is typically collected through interviews but can also involve other data sources such as surveys, documents, objects, drawings, or observations. The researcher then reduces all the data into significant statements and combines them into themes. This reduction ends with a detailed description that captures the essential nature, or essence, of "what" people experience (textural description) and "how" they experience it (structural description) (Moustakas, 1994).

Moustakas and others (Moustakas, 1994; e.g., van Manen, 2016) have identified several common assumptions of phenomenology:

- It is the study of lived experiences.
- Those lived experiences are conscious.
- An essence of shared lived experiences exists.
- Phenomenology involves the development of descriptions but not causal or other types of explanations.

During the process it is important that the researcher brackets out their own experiences by clearly describing their background with the phenomenon (positionality) so that they do not interfere with the current study (Giorgi, 2009). Van Manen referred to this approach as "phenomenological reflection" while Husserl identified it as *epoche* (Moustakas, 1994).

Mixed Methods

Creswell and Creswell defined mixed methods as "an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data" (Creswell & Creswell, 2018, p. 4). A primary assumption of mixed methods is that the integration of the two forms of data results in understanding beyond either the quantitative or qualitative data alone (Creswell & Creswell, 2018). This approach is most appropriate for this study as it allows for qualitative methods to answer the first research question, how science is re/presented in science museum exhibits, and quantitative methods, using data from the qualitative phase, to answer the second research question, how science museum exhibits contribute to perceptions of belonging.

Qualitative Methods

Denzin and Lincoln (2011, p. 3) describe qualitative research as an “interpretive, naturalistic approach to the world” in which researchers study phenomena in a natural context and the “meanings people bring to them.” Qualitative methods are often more sensitive when trying to understand complex issues in context (Creswell & Poth, 2018), and because data suggest that museum experiences for White and POC visitors differ based on demographics, this approach allowed for a more detailed and nuanced exploration of this critical need to empower individuals in the science museum. Data was collected in a natural setting through observations. Features from the qualitative phase were chosen to test in the quantitative phase.

Quantitative Methods

A mostly quantitative survey was used to test features identified in the qualitative phase. A survey design allows for a quantitative description of trends and opinions of the sampled population (Creswell & Creswell, 2018). Surveys work well when answering questions about the relationship between variables as in this study. A survey is useful in helping the researcher make inferences about those relationships and generalize the results to a more extensive population (Creswell & Creswell, 2018).

Positionality

The phenomenon of belonging, inclusion, and equity is most often experienced by members of traditionally marginalized groups (e.g., People of Color, LGBTQ+, disabled) but can happen to anyone, especially when they find themselves in the minority, even temporarily. This researcher is a 59-year-old White woman. I am well-educated and, as a child, lived and still live a financially comfortable life. I have chosen to pursue careers in science, first as a research assistant in a laboratory and then as a middle school teacher. While many women report experiencing exclusion and inequity as members of the science community, I fortunately have not. As a teacher, I understood that many of my students, especially students of color and girls, felt excluded from the science community, and I worked hard to provide opportunities for them to belong by offering after school science clubs, coaching a science competition team, relating science events and camps to parents, and enthusiastically writing letters of recommendation. I acknowledge that position of power and privilege afforded me the ability to support the goals and needs of others.

In my adult life I seldom find myself in the minority either in terms of my gender or race. I am going to relate, though, two very different experiences I have had when I have felt exclusion and a lack of belonging.

As a graduate student in Washington, DC, I traveled by metro to Howard University to gather data for a research project. Howard is an HBCU (Historically Black College and University) with a 97% POC student demographic. I exited the Shaw-Howard University station, and I did not see another White person for the next few hours as I walked to the library, worked with the librarian to find what I needed, and returned to the station. It was clear to anyone that, racially, I did not fit in, and I felt very self-conscious. I was sure that everyone I passed wondered what I was doing there, secretly wishing me back to where I came from. The truth, though, was that no one gave me a second look. I was treated no differently than I was on any other day. People on the street ignored me for the most part, the librarian was kind and helpful, and the other metro commuters appeared concerned only with getting where they needed to go.

During this event, the phenomenon of exclusion and lack of belonging was perceived and experienced only by me (the outsider) and not perpetrated by those around me. There was nothing I needed to do to be afforded insider status (at least on the surface).

When I was 37, I desired a change in my life, so I moved to Nara, Japan, to teach English for a year. Nara is a former Japanese capital, so it is a popular tourist destination. It was not unusual to see non-Japanese people around the school where I worked, on the train, and in shops and restaurants. But when I was near my apartment or traveling by bus or train to less touristy destinations, I could go a whole day without seeing another non-Japanese person. The racial demographics of the country are 98% native Japanese. In Japanese, the word *gaijin* literally means “outside person” and is used to describe both foreigners and citizens of non-Japanese descent. On the train, it was not unusual to be stared and pointed at. Learning how to get around and perform daily tasks (grocery shopping, banking, buying train tickets) took about 3 months to feel proficient. I distinctly remember sitting on a train and thinking how I finally fit in. I also noticed that the other commuters still stared and pointed at me the way they did when I first arrived. Despite my growing feelings of belonging, capacity, and inclusion (“I know what I’m doing.”), it was clear that those around me did not include me as one of them. No matter how capable I appeared, I was not perceived that way. During this event, the phenomenon of belonging and inclusion was experienced by me (outsider becoming insider), but exclusive behavior was still perpetrated by those around me. I got the sense that there was nothing I could do (speak Japanese fluently, appear confident, move around, perform cultural and social routines competently) that would afford me insider status.

These experiences reveal that there are two perspectives to the phenomenon under study: the outsider assuming, seeking, or hoping for insider status (inclusion, belonging), and the insider group barring (exclusion, alienation) or affording (inclusion, belonging) insider status to the outsider. Both are critical parts to community equity.

Research Design

The science museum served as the context for this study. Data were collected from 3 museums and from community members who reside in the same geographical area as those museums. Two types of data were collected and analyzed for this study: 1) observational data were collected from the exhibits at three science museums in central NC, and 2) survey data were collected from the public (Table 3.1). Data analysis consisted of qualitative thematic coding of the observational data (and a few open-ended survey items) and quantitative statistics of the survey data.

Table 3.1

Research Questions (RQ) Mapped to Data Sources.

Research Question	**Data Source**
RQ1: How is science (re)presented in science museums? In text? In images of people?	Observations
RQ2: How does the way science is (re)presented in science museums contribute to perceptions of belonging and inclusion?	Observations, Survey

Qualitative Data Collection and Analysis

Qualitative data was collected through exhibit observations using a systematic protocol (Appendix B). These observations resulted in text and image data. Text data was deductively and inductively coded resulting in 7 parent codes including Science Discourse, Nature of Science, and Science Practices. Image data was deductively coded for apparent race and gender and type of science which included Professional Science and Everyday Science.

Observations

While observations are reliant on the subjective nature of perception, they allow for a sensitive and detailed examination of phenomena in context when a systematic approach is used. Merriam and Tisdell (2015) cite several reasons to use observations as a data collection tool that are relevant to this study: they can bring a novel perspective to something that has become routine; used with other data sources, they can be used to triangulate other findings; and they can be used as a reference point in later interviews (sometimes called anchored interviewing) especially for topics that may be difficult to discuss.

What to observe is usually determined by the study's research questions, framework, and problem. In this case, observations were focused on the physical components of the exhibit (text and images) and the museum exhibit in context. The observations did not include visitors, activities or interactions, or conversations. A protocol (Appendix A) was developed that captured relevant information: topic, target audience, textual details, images (drawings and photos), descriptions of objects, physical accessibility, and physical setting and arrangement. In addition, exhibits were examined for cultural responsiveness: efforts to acknowledge and redress bias and evidence of the museum's cultural lens (Muñiz, 2019). The observation also includes observer comments about the researcher's thoughts, impressions, and perceptions of the exhibit and its content. Observations took as much time as needed to thoroughly complete the protocol and typically took 60-90 minutes. To retain as much detail as possible, notes and reflections were written up as soon as possible following the observation.

Because the observations did not involve people, there was little concern about gaining access to the subject of the observation, the museum exhibit. Nevertheless, the researcher wished to take care to respect the organization's involvement. Therefore, the researcher was ready to answer questions related to the observations. No concerns from organizations arose before, during, or after observations.

A total of 6 exhibits were observed at the 3 museums chosen. The process of observation was overt and took place when the exhibit was not crowded to improve researcher access. The researcher entered the exhibit and moved in a logical manner to collect all the information detailed in the protocol (Appendix A), including what's observed and what's not observed. In addition to the completed protocol, the researcher drew a detailed map of the layout (including the path taken within) and took photos and video of any visual aspects of the space. The researcher was also clear about how their presence may affect the observation and how they will account for those effects in interpreting the data (Merriam & Tisdell, 2015).

Text Coding

Exhibit text was analyzed using qualitative analysis software Atlas.ti and the constant comparative method (Glaser & Strauss, 2017). Text codes were developed both inductively and deductively. Deductive codes were created a priori and were based on the researcher's experience and the literature (e.g., NGSS Lead States, 2013). Inductive codes were developed in response to RQ1: how is science re/presented? The coding segment was typically the sentence, and a segment could be coded in multiply ways (e.g., process discourse and local science connection). As new codes were developed or amended, previously coded text was reanalyzed to include the new or amended codes. Once coding reached saturation (no new codes emerging),

Table 3.2

Summary of Text Coding.

Code	Subcode	Code Definition
Connection	Ethnic Science	Science concepts connect to non-US-dominant culture or a non-US geographical region.
	Local Science	Reference to science that has taken place in the state or nearby.
	Science Benefits People	Reference to science that affects people in a positive way.
	You Try It	Exhibit explicitly invites the visitor to carry out some scientific practice.
Discourse	Process	Science as process describes a process, *how* science is done.
	Product	Science as product describes scientific knowledge, *what* science is.
Nature of Science	Certainty	Science knowledge is sure, right, or unopposed.
	Controversial	Science can have opposing perspectives that people disagree about.
	Curiosity	People who carry out science are curious and eager to learn.
	Evidence	Science knowledge is based upon logical and conceptual connections between evidence and explanations.[2]

Table 3.2 (continued).

	Human Endeavor	Scientific knowledge is a result of human endeavor, imagination, and creativity.[2]
	Humans and Nature	There are times when humans are connected to nature, both positively and negatively.
	Impermanent	Science findings are frequently revised and/or reinterpreted based on new evidence.[2]
	Improved by Technology	Science is improved by technological advances.
	Real-time	Scientific information is collected in real time and can be used immediately.
	Science History/Stories	Scientists have stories about their lives and work; science affects the present and the past.
	Revealing	Science knowledge is uncovered or revealed through exploration or experimentation.
Practices	Analyzing/Interpreting Data	Scientific investigations produce data that must be analyzed in order to derive meaning.[1]
	Asking Questions	To ask and refine questions that lead to descriptions and explanations. [1]
	Constructing Explanations	The products of science are explanations.[1]

Table 3.2 (continued).

	Modeling	To use and construct models as helpful tools for representing ideas and explanations.[1]
	Argument	Argumentation is the process by which explanations are reached. [1]
	Using Information	Scientists must be able to communicate clearly and persuasively the ideas and methods they generate.[1]
	Using Math/Computational Thinking	In both science, mathematics and computation are fundamental tools.[1]
	Planning/Carrying Out Investigations	To plan and carry out investigations in the field or laboratory. [1]
	Making Predictions	To make predictions about future events or the results of experimentation.
	Collecting Data	To gather data through study, observation, or measurement.
Voice	First person *inclusive* (plural)	Use of the pronouns "we/us" and implies inclusion of the reader.
	First person *exclusive* (singular and plural)	Use of the pronouns "I/me" or "we/us" and implies exclusion of the reader.
	Second person *inclusive* (singular and plural)	Use of the pronouns "you/y'all" and implies inclusion of the reader.

Table 3.2 (continued).

	Second/Third person *exclusive* (singular and plural)	Use of the pronouns "you/y'all" or "they/them" and implies exclusion of the reader.
	Passive	Use of the passive voice where the subject undergoes the action of the verb.
Type of Science	Professional	Professional science is done by people who do science for a job.
	School	School science is done or learned by people in school.
	Everyday	Everyday science can be done by anyone.
Use of Language	Analogy	To make a comparison between two things, one scientific and the other not scientific.
	Poetic Science	Use of rich, aesthetic language meant to provoke emotion or reflection.

1 NGSS Lead States (Science and Engineering Practices), 2013

2 NGSS Lead States (Nature of Science), 2013

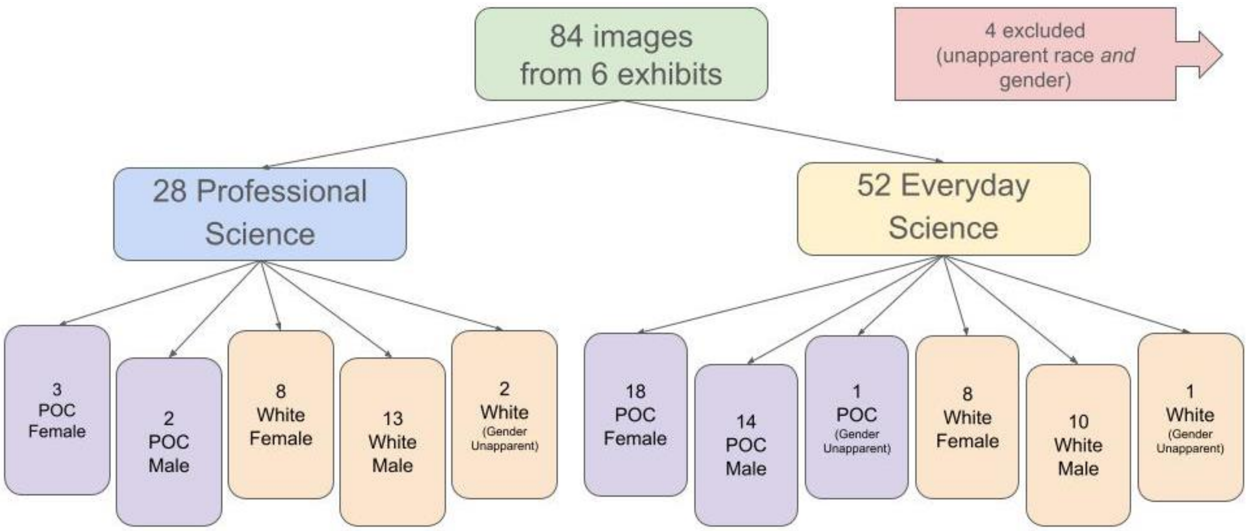
similar codes were collapsed, and all codes were organized and grouped under categories. Ultimately, seven categories, or parent codes, containing 39 subcodes were created. Codes, subcodes, and code definitions are presented in Table 3.2.

Image Coding

Images from the six exhibits were included if they depicted a person or part of a person (e.g., hand, head). Eighty-four images were selected (see Figure 3.2). Qualitative visual analysis was used to identify the apparent race/ethnicity and gender of each person depicted as well as the type of science depicted. The images were coded using the constant comparative method (Glaser & Strauss, 2017).

Figure 3.2

Image data for coding.



This researcher acknowledges that race and gender are both social constructs and that the creation and separation of either into distinct or binary categories is complicated (Krylova, 2016; Haslanger, 2000). Nevertheless, people can and do make assumptions about visual identities such as race and gender (e.g., Feliciano, 2016), and apparent diversity is an important consideration when examining equity, inclusion, and belonging (e.g., Scheuerman et al., 2020). In the literature prior to 2000, coding of race and gender often was either defined poorly or completely undefined. These studies coded race and gender according to physical appearance (e.g., Ferree & Hall, 1990), More current studies that do attempt to define race codes, often depend on skin tone but also hair texture and eye shape (e.g., Clawson & Kegler, 2000). Gender coding schemes most often cite physical appearance in combination with hairstyles, clothing, and fashion accessories (e.g., Rose et al., 2012). Data was manually coded using *a priori* codes.

Codes for apparent race/ethnicity were POC, White, or not apparent. Codes for apparent gender were Female (or Feminine), Male (or Masculine), or not apparent. Code definitions were

Table 3.3

Image Coding Summary.

Code	Subcode	Code Definition
Type of Science	Professional Science	Image depicts a person who appears to do science for a job in a lab or in the field and appears to be engaged in scientific practice.
	Everyday Science	Image depicts a person who does not appear to be engaged in scientific practice but in everyday activities.
Apparent Race/Ethnicity	White	Image depicts a person with lighter skin, straighter hair, lighter hair, lighter eyes, narrower nose, and/or thinner lips.
	Person of Color (POC)	Image depicts a person with darker skin, curly/kinky hair, darker hair, epicanthic fold, wider nose, and/or fuller lips.
	Not Apparent	Image depicts a person whose features are either not visible or not clearly POC or White.
Apparent Gender	Masculine/Male	Image depicts a person with facial/chest hair; heavier/more angular brow, cheekbones, and jaw; more muscular build; traditional masculine attire (jacket/tie); shorter hair; no breasts; and/or taller height.
	Feminine/Female	Image depicts a person with no facial hair; wider hips; more rounded facial features; less muscular build; traditional feminine attire (dress, skirt); longer hair; breasts; and/or shorter height.
	Not Apparent	Image depicts a person whose features are either not visible or not clearly Female or Male.

dependent on visible social markers (clothing, hairstyles) and physical features, and coding required coders to make assumptions when assigning apparent race and gender. In several images it was difficult to assign apparent race and/or gender (e.g., only hands visible, hands wearing gloves, child wearing a bike helmet). Images of people whose race *and* gender were not apparent were not included in analysis. There were no images that depicted people who appeared nonbinary. There were no images that depicted people whose race was not apparent (to the author).

The type of science was coded as either professional science (i.e., science done by scientists) or everyday science (i.e., science in everyday life). Code descriptions and examples can be found in Table 3.3. Depicted activity was not coded (e.g., cooking, playing football).

Because I was interested in comparing representation of the culturally dominant race (in this case, White), the code for all other culturally marginalized races (POC) was not disaggregated (e.g., Black, Latinx, and Asian). The coding unit was an individual person in each image. In some cases, images had more than one person depicted and so had multiple codes.

Museums and Exhibits

Three North Carolina science museums were purposefully chosen to represent a range of size (large, medium, and small based on annual attendance), type (public and private), racial demographics of the surrounding community, and location (small, medium, and large cities) (see Table 3.2). The three museums chosen were the North Carolina Museum of Natural Sciences (NCMNS), the Museum of Life and Science (MLS), and the Morehead Planetarium and Science Center (MPSC). It was important to my study that I strived to gather data from museums that might be considered representative thereby increasing the possibility of transferability (Shenton, 2004). Descriptions of the museums contain information that is publicly available on the organization's website. Additional information was gathered during in-person visits. The museums were also chosen because observed exhibits were developed "in-house," ostensibly with the local community's needs and desires considered. Thick rich descriptions of the exhibits were written after each museum visit (Geertz, 1973).

Table 3.4

Summary of Selected Museums.

Museum	City Demographics				Type/Cost	Annual Attendance
	Population	% White	% Latinx	% Black		
NCMNS	464000	53	11	28	Public/free	1.2 mil
MLS	270000	40	14	38	Private/ $20	560,000
MPSC	62000	55	11	26	Public/$10	10,000
State (NC)	-	63	9	21	-	-
US	-	61	18	12	-	-

At each museum, exhibits were purposefully selected to represent a variety of typologies and topics (Table 3.5). Choosing a variety of exhibit typologies allowed me to examine if and how typology might affect inclusion and belonging. Three exhibits featured life science (DNA, health, and NC animals), 2 exhibits featured earth science (weather and fossils), and 1 exhibit featured physical science (light). All exhibits could be considered pedagogical, 3 exhibits also featured interactive components and were experiential, and 1 exhibit featured underrepresented scientists so could be considered critical.

The first two exhibit typologies, pedagogical and experiential, were initially described by Wellington. "The pedagogical category essentially sets out to teach something to the visitor (e.g., position of organs in the body, digestive system, separation of dyes by chromatography, reflection of light, rock classification) and is dominant in first- and second-generation museums. The experiential exhibit allows the visitor to experience (and perhaps interact with) phenomena (e.g., soap bubbles, whirlwinds, water vortices) – this latter group is often rooted in second generation science museums" (Pedretti & Iannini, 2020b, p. 57).

Table 3.5

Summary of Exhibits.

Exhibit Name	Topic	Type	Location
How We Know...the Past	fossils	pedagogical	NCMNS
Unraveling DNA	DNA	pedagogical	NCMNS
Researching Weather	weather	pedagogical	NCMNS
Carolina Wildlife	local animals (live)	pedagogical/experiential	MLS
Investigating Health	health	experiential	MLS
Hidden No More	light	experiential/critical	MPSC

Pedretti described two additional typologies: critical (2002) and agential (2020). Critical exhibits "speak to the processes of science, the nature of science, and science and technology in its socio-cultural context [and may be] issues-based, inviting visitors to participate actively, consider socio-scientific issues from a variety of perspectives, and critique the nature and practice of science and technology" (Pedretti, 2002, p. 9). "Responsible citizenship, informed decision-making, action, and activism are hallmarks of the agential typology whose exhibits encourage growth in visitors' political literacy and action and eventual change in their lives and communities (Pedretti & Iannini, 2020, p. 60).

Exhibits were characterized by these 4 typologies in addition to a typology that may be missing, the researcher-created relevant/asset-based typology. Asset-based exhibits may contain aspects of each of the other typologies but are defined by the researcher as having been co-created by community members with an asset-based mindset rather than a deficit mindset. The asset-based mindset acknowledges and values the knowledge that members of the community bring to the museum context. These exhibits are also highly relevant to the community compared to other exhibits.

North Carolina Museum of Natural Sciences (NCMNS)

The North Carolina Museum of Natural Sciences is in urban Raleigh, NC, a large city whose Black and Hispanic population is approximately 39% which is similar to the state's (30%) (US Census Bureau, 2019). It is a large public museum that does not charge visitor admission. NCMNS has an annual attendance of over 1 million and serves visitors of all ages, including students, and teachers through its professional development programming. Three floors contain "exhibits and live animal displays reveal North Carolina's rich natural habitats, wildlife and geology from the Appalachian Mountains to the Atlantic Ocean" (NCMNS, n.d.). The museum also contains a research center that allows visitors to directly observe museum researchers engaged in exploration. NCMNS has several satellite facilities, but this study will focus only on the main museum. Nearly 200 staff are employed by the museum.

Since 2014, the museum's mission has been "to illuminate the natural world and inspire its conservation" (NCMNS, n.d.). While the organization's website does not display a DEI statement, it includes a statement supporting the Black Lives Matter movement, information about the RACE: Are we so different? exhibit, and a commitment to accessibility.

Exhibit #1: How We Know About the Past. This exhibit is a typical pedagogical exhibit about fossils. The content is arranged in panels along a curved wall. Panels describe how fossils form, different types of fossils, what fossils can tell us, and where in the state fossils are found. Written text is supported by both fossilized objects (bones, shells, coprolites) and images (maps, diagrams, photos) (Figure 3.3).

Figure 3.3

Examples of exhibits from How We Know About the Past.

Exhibit #2: Unraveling DNA. This exhibit is another typical pedagogical exhibit about DNA. Content is arranged around a central hub with sections devoted to model organisms, coding, mutations, translation and transcription, and similarities to other species (Figure 3.4). There are many colorful photos and diagrams.

Figure 3.4

Examples of exhibits from Unraveling DNA.

Exhibit #3: Researching Weather. This exhibit is pedagogical with a large experiential component. Content, like the DNA exhibit, is arranged around a central hub with sections on many tools for measuring weather and natural records of weather history (e.g., ice cores) (Figure 3.5). There are many colorful photos and diagrams.

Figure 3.5

Examples of exhibits from Researching Weather.

Museum of Life and Science (MLS)

The Museum of Life and Science is located in Durham, NC, in a suburban area of the medium-sized city whose Black and Hispanic population is approximately 52%, greater than the state's (US Census Bureau, 2019). It is a moderately-sized private museum that charges $20-25 per adult visitor. MLS has an annual attendance of more than 500,000 and serves visitors of all ages. It contains indoor and outdoor exhibits on a variety of physical, life, and earth science topics. The museum employs 50 staff.

The museum's mission is "to create a place of lifelong learning where people of all ages embrace science as a way of knowing about themselves, their community, and their world" (MLS, n.d.). The organization's website does not display a DEI statement but does state that they are "committed to building and strengthening a culture of diversity and inclusion" (website). There is also abundant information on accessibility including resources for visually impaired visitors and visitors with autism and sensory challenges.

Figure 3.6

Examples of exhibits from Carolina Wildlife.

Exhibit #1: Carolina Wildlife. Carolina Wildlife is a pedagogical exhibit about some of the area's mammals, birds, and reptiles (Figure 3.6). Its purpose is to improve understanding and knowledge of local animals including range, diet, identification, and behavior.

Exhibit #2: Investigate Health. Investigate Health is a largely experiential exhibit focused on strategies to improve personal health. Content is arranged throughout a small corner of the museum. There are sections on wearing seatbelts, handwashing, biofeedback, dust mites and allergies, and sunscreen. Each section has some interactive component (Figure 3.7). For example, in the Investigate Sunscreen section, visitors can test the effectiveness of sunscreen in blocking UV radiation by comparing their hands before and after applying a UV-blocking cream and examining them under UV light. Unlike many other exhibits in the museum, text is presented only in English. Content is targeted for the general public, and experiential aspects can

Figure 3.7

Examples of exhibits from Investigate Health

be experienced by all visitors, but some text is written at the upper middle school level and may need adult assistance to understand. Photos depict a diversity of racial and ethnic groups and a balance of genders and ages. There is a strong human connection in this exhibit as the content focuses on human health. There is not a strong local connection in any exhibit component. There is no attempt to connect to marginalized groups or nondominant culture or to recognize and redress bias.

Morehead Planetarium and Science Center (MPSC)

The Morehead Planetarium and Science Center is located on the main street of Chapel Hill, NC, a small city which surrounds a large public university. The Black and Latinx population is 37% which is similar to the state's (30%) (US Census Bureau, 2019) and the city surrounding the MPSC described above. The museum is on the campus of and associated with the university. It is a small museum with its largest component being a state-of-the-art planetarium. The museum also performs outreach across the state. Entrance to the museum costs $11 for adults, and annual attendance is approximately 10,00 visitors.

The museum's mission is "to serve [the state] and beyond by bringing together the unique resources of the [university] to engage the public for an enhanced understanding of science." The museum has also published statements concerning its vision, values, and commitment to inclusion.

Exhibit: Hidden No More. Hidden No More was developed as a traveling or non-permanent exhibit, so the layout differs depending on the installation. The exhibit has many experiential components including a rather ambitious virtual reality (VR) element. The overall content focus is the science of light, but the exhibit also strives to expose the work of underrepresented scientists (women, POC, and persons with disabilities) (Figure 3.8). The exhibit plans to highlight 8 scientists in total (4 historical and 4 current) and thus far has content on two. Text content is presented in both English and Spanish. The VR element is in English only. Content is targeted for the general public, and experiential aspects can be experienced by all visitors, but some text is written at the upper middle school level and may need adult assistance to understand. The only depictions of people are of the featured underrepresented scientists. There is a strong human connection in this exhibit as the content focuses on the work of specific scientists. There is a local connection to one of the featured scientists who completed graduate work at a local university. There is strong connection to marginalized groups and nondominant culture as the exhibit strives to “continually highlight the range of contributors [from underrepresented groups] to STEM fields today and throughout history,” and therefore works to recognize and redress bias.

Figure 3.8

Examples of exhibits from Hidden No More.

Qualitative Reliability

Because qualitative research cannot easily be subjected to the same standards of validity and reliability as quantitative research, Guba (1981) created criteria for qualitative research that correspond to common measures of trustworthiness in quantitative research, and Shenton (2004) describes strategies that the qualitative researcher can use to address each criterion. Table 3.6 includes those of Shenton’s strategies that were used in this research and how they were employed.

Table 3.6

Corresponding criteria for research.

Quantitative	Qualitative[1]	Strategy[2]	How Employed
Internal validity	Credibility	Use of well-established research methods.	This research is guided by the methods of established qualitative methodologists (e.g., Merriam & Tisdell, 2015).
		Familiarity with the culture of participating organizations.	Prior to collecting data, the researcher will establish a relationship with participating museums.
		Triangulation	Three data sources (exhibit observations, educator interviews, and community focus groups) will be used to triangulate results.
		Use of tactics to help ensure honesty in informants.	Participants can remove consent at any time and are not required to answer any questions. Participants are ensured anonymity and confidentiality.
		Peer scrutiny of the research project and frequent debriefing sessions	Methods and coding will be subjected to peer review, and weekly meetings with advisor will occur.

Table 3.6 (continued).

		Thick description of the phenomenon under scrutiny.	The researcher uses thick rich descriptions of exhibit observations (and other data).
External validity	Transferability	Ensure that sufficient contextual information about the data collection is provided to enable the reader to make a transfer.	The researcher provides detailed information on museum sites, exhibits, participants, and methods to increase the possibility of transferability.
Reliability	Dependability	Section devoted to research design and its implementation.	See "Approach" and "Context and Participants" sections.
		Section devoted the operational detail of data gathering	See "Data Collection" section.
Objectivity	Confirmability	Ensure as far as possible that the findings are the result of the experiences and ideas of the participants, rather than the characteristics and preferences of the researcher.	See "Positionality" section.

1 Guba, 1981

2 Shenton, 2004

Quantitative Data Collection and Analysis

Survey Instrument

According to Groves (2011), a survey is a "systematic method for gathering information from (a sample of) entities for the purposes of constructing quantitative descriptors" (i.e., statistics). These statistics include descriptive statistics such as mean and analytic statistics which measure how variables may be related (Creswell & Creswell, 2018; Groves, 2011).

The survey for this study consisted of 34 items (see Appendix B). Survey items were aligned to the research questions and to qualitative codes developed from the exhibit text. The draft survey was piloted with 3 colleagues using a concurrent "think aloud" process (e.g., Ryan et al., 2012) wherein pilot testers verbalized their thinking as they completed the survey. Additional retrospective piloting was completed with individuals who were similar to the prospective sample where feedback was provided after survey completion. Based on pilot tester's feedback, iterative edits were made for clarity and accuracy. Nineteen of the items were close ended (Likert scale and multiple choice) and 15 were open-ended. The open-ended items required only short answers. There were 4 sections in the survey.

Leisure Time Activities

The first section asked respondents about their leisure activities including the frequency of their museum-going. Choices of leisure activities included shopping, athletics, outdoor activities as well as visiting museums. They were also asked for the reason for their museum-going frequency (both high and low).

Contextual Belonging

The second section asked respondents about their perceptions of inclusion and belonging in the museum setting. Respondents rated their agreement to a series of statements on a 5-point Likert scale from strongly disagree to strongly agree. Within this section, the researcher aligned the first group of statements with Falk and Dierking's Contextual Model of Learning, which is used to explore learning in informal settings (Falk & Dierking, 2016). The model consists of three parts: physical context (e.g., "signs and maps were helpful"), sociocultural context (e.g., "other guests were respectful"), and personal context (e.g., "the exhibits were interesting and relevant to me"). The second group of questions in this section were developed by Price and Applebaum (2022) as part of their Cultural Context Belonging Scale and specifically address belonging in museums. Finally, in this section, respondents were asked if there were other things museums did or could do to increase their sense of inclusion and belonging (open response).

A/B Messaging

The third section presented respondents with pairs of sample texts in an A/B messaging format. One sample was taken verbatim from an exhibit, and the other sample was altered to increase or decrease perceptions of belong, inclusion, and equity in the reader. The changes were based on codes developed during exhibit text analysis. These themes included Connection (local, personal, cultural), Nature of Science (specifically Science as a Human Endeavor), and Science Voice (first person vs. second or third person, inclusive vs. exclusive) (See Table 3.7).

Table 3.7

Survey text comparison (*with changes in italics).*

Pair	Original Text Sample	Altered Text Sample	Tested Code(s)
1	Crocodiles and alligators can be mistaken for each other, but there are differences. In the photo above, the American crocodile has a longer, thinner head than the American alligator.	Crocodiles and alligators can be mistaken for each other, but there are differences. *Look carefully* at the photos of their heads. *What do you notice* about the shape? One of them has a long thin head. That's a crocodile!	Connection: you try it (look, notice) Science voice: inclusive second person (you) Discourse: process vs product (collect data vs facts)

Table 3.7 (continued).

2	You can shade your skin with umbrellas, clothing, and even sunscreen. The chemicals in sunscreen provide invisible shade for your skin.	*We can shade our skin* with umbrellas, clothing, or even *the shadow of a tree*. We can also use sunscreen which has special chemicals that block the sun's harmful ultraviolet rays *which can damage the cells of our skin and even possibly cause disease*.	Science voice: inclusive second person (we) Connection: ethnic science Connection: science benefits people
3	Wearing a seatbelt makes survival in a car crash twice as likely. Seatbelts work best when they fit across the chest and shoulders and down low over the hips.	*We're twice as likely* to survive a car crash if we're buckled up properly. Seat belts work best when they fit across *our chests and shoulders* and down low over *our hips.*	Science Voice: first person inclusive (we)
4	Most of these rocks are Precambrian, an age before organisms developed the hard parts that fossilize. However, rare fossils and traces of soft-bodied organisms can sometimes be found.	It is difficult for *paleontologists* to find fossils from the Precambrian period. During this time, most animals had soft bodies, so they didn't leave behind many fossils to find. *Have you ever discovered a fossil?*	NOS: science as human endeavor (paleontologists) Connection: you try it (question)

Table 3.7 (continued).

5	A Persian scientist named Al-Farisi wondered about how rainbows form. He knew that light and color were connected. When light strikes objects of different colors, some wavelengths are absorbed, and others are reflected.	A Persian scientist named Al-Farisi became curious about a question that had baffled scientists for many years. How are rainbows formed? He *conducted experiments* with a model of a raindrop -- a water-filled glass sphere. And he found the answer!	NOS: Science as Human Endeavor (he conducted experiments) Practices: planning and carrying out investigations (conducted experiments) Discourse: process vs product (collect data vs facts)
6	The ability to determine the organization of the DNA code sequence has been one of the greatest technological breakthroughs in science.	Sequencing human DNA has helped *scientists* diagnose, treat, and even *cure diseases that affect us such as allergies, cancer, and even the common cold*.	NOS: science as human endeavor (scientists) Connection: science benefits people (cure diseases)
7	What's the weather? It's a critical question, and an immense amount of information is used to answer it every day. A constant stream of data is analyzed by computers to forecast tomorrow's weather and to improve predictions of the future.	What's the weather? It's a really important question, and weather *scientists work hard* to answer it every day. *Meteorologists analyze* a constant stream of data, *with the help of computers*, to forecast tomorrow's weather and to improve predictions about *our future*.	NOS: science as human endeavor (scientists, meteorologists, with the help of computers) Practices: analyzing and interpreting data (analyze) Science Voice: first person inclusive (our)

Table 3.7 (continued).

8	Trees put on a ring of new growth every year. If the ring is wide, the average weather was good, and if it's thin, the average weather was cold and dry. Trees are very sensitive recorders of yearly climate.	*Look at the section* of a tree from the mountains of North Carolina. *Can you find wide rings?* They tell *climatologists* that the average weather at that time was good. *What do you think thin rings tell us?* Trees can give us a lot of *evidence about climate* in the past.	Connection: you try it (look, can you, what do you think) NOS: science as human endeavor (climatologists) NOS: based on evidence (evidence) Discourse: process vs product (collect data vs facts)

Respondents were asked to rate the texts according to how much each statement made them feel inclusion and belonging on a 5-point Likert scale from not at all to a great deal. They were then asked to explain their choices in an open response.

Sociodemographics

The fourth and final section asked respondents for demographic data including gender, race, income, and education.

Survey Participants

The participants in the survey portion of this study were recruited from the general public. Participants were recruited from a variety of sources including a parent Facebook group, a neighborhood email listserv, and snowball recruiting from friends and colleagues.

Participants were at least 18 years old and consented to participate in an online survey. Because the majority of museum visitors are White and female, an effort was made to purposefully recruit participants who self-identify as 1) members of a racial/ethnic group underrepresented in museum attendance (particularly Black/African-American or

Latinx/Hispanic), 2) infrequent museum visitors (defined as 2 or fewer times per year) or nonvisitors (defined as no attendance in the past 2 years), and/or 3) non-female.

There were 115 full or partial responses to the survey. Because the research questions depend on being able to disaggregate the data (POC vs White), surveys that did not contain demographics were excluded. After exclusions, 61 responses remained.

Table 3.8

Summary of Survey Participants.

Characteristic	Category	Frequency	Percent
Age	18-25	1	<2
	26-35	16	26
	36-45	24	39
	46-55	9	15
	Over 55	11	18
Race/Ethnicity	Latinx/Hispanic	16	26
	Black/African American	7	11
	Asian	2	3
	White (non-Hispanic)	33	54
	Another Race/Ethnicity	3	5
Gender	Female	51	77
	Male	15	23
	Another Gender	0	0
Education Background	HS or some college	1	<2
	Associate’s degree	1	<2
	Bachelor’s degree	20	33
	Post-graduate degree	38	62
	Another form of education	1	<2

For age, the category with the most respondents was 36-45 (39%). 15-26% of respondents fell into the 26-35, 46-55, and 55+ categories. Only 3% of respondents fell into the 18-25 category. Despite researcher efforts to increase POC respondents, 54% were White and only 46% POC. Most respondents identified as Female (77%), and no respondents identified as a gender other than Male or Female (Table 3.8). Almost all respondents possess a Bachelor's degree or a postgraduate degree (95%). Most respondents live in an urban or suburban area (87%) in North Carolina (85%). The income of respondents ranged from under $25,000 to over $200,000 with the most falling into the categories of $100,00-149,000 and $150,000-199,000.

Survey Data Analysis

Quantitative analysis was used to evaluate close-ended questions. Quantitative calculations included frequencies and descriptive statistics (Urdan, 2017). Student's t test was used to compare the means of the text ranking (Urdan, 2017).

Qualitative analysis was used to identify the reasoning behind Likert scale choices. Data was manually coded through a combination of *a priori* and *in vivo* coding. *A priori* codes were developed mainly through experience with the museum community and from the literature (e.g., Feinstein & Meshoulam, 2013). *In vivo* coding allowed for the addition of other codes as needed. The coding segment was the question response for each respondent. In most cases, this was a sentence or a partial sentence. These segments were coded using the constant comparative method (Glaser, 1964). Coding was continued to saturation.

Survey Reliability and Validity

Reliability of Constructs

Survey reliability measures consistency of the items of each underlying theme, or construct, that the survey aims to measure. This survey contained 2 constructs, Contextual

Belonging Scale, modified from Applebaum and Price, and Contextual Model of Learning Scale, modified from Falk and Dierking. Each construct contained 9 items. Reliability was measured using Cronbach's alpha and is shown in Table 3.9. Values for each construct and for all items are in the range for acceptable reliability of 0.70-0.90 (Tavakol & Dennick, 2011).

Table 3.9

Reliability of Survey Constructs.

Variable	Cronbach's Alpha	N of Items
Cultural Context Belonging Scale[1]	0.808	9
Contextual Model of Learning Scale[2]	0.739	9
All Items	0.859	18

1 Price and Applebaum, 2022

2 Falk & Dierking, 2016

Validity of A/B Messages

Validity refers to something measuring what it claims to measure. In this case, the text segments were altered in a way that the author thought would increase perceptions of belonging in the reader. Three colleagues face validated each of the 8 segments and agreed that the alterations should ostensibly increase perceptions of belonging.

Ethical Considerations

Protocol #25132 and a subsequent amendment were approved by the NC State Institutional Review Board (IRB). The protocol included the informed consent for participants, recruitment plans, and survey instrument. All survey participants consented to research activities as outlined in the IRB protocol.

CHAPTER 4: RESULTS

The results of the quantitative survey and qualitative observations are presented in this chapter. These results include descriptions of respondents' visiting behavior as well as their perceptions of belonging and to what extent they attribute those perceptions to museum exhibits. Thick, rich descriptions of the chosen exhibits as well as qualitative coding of exhibit text and images of people are also given.

- RQ1: How is science re/presented in science museums?
  - In exhibit text?
  - In exhibit images of people?
- RQ2: How does the way science is re/presented contribute to perceptions of belonging and inclusion for visitors (current and potential) of science museums?

Research Question 1: Exhibit Observations

Exhibit Text Coding Summary

Across all exhibits, 699 segments were assigned more than 1000 codes (Table 4.1). Overall, several codes were more prevalent than others. The code Science Discourse appears over 400 times with the subcode Product appearing more than 3 times as often as Process. Under the code Connection, the subcode Local Science appeared about twice as often as the next two frequent, Science Benefits People and You Try It. NOS codes were very dependent on exhibit. The most prominent NOS codes were Evidence, Human Endeavor (and Nonhuman Work), and Humans/Nature. Several NOS subcodes rarely appeared in any exhibit including Uncertainty, Impermanent, and Controversial. Of the Practices subcodes, Collecting Data appeared 2-3 times more often than any others. The three most common were Analyzing, Asking Questions, Carrying Out Investigations. Several of the NGSS derived subcodes (Developing/Using Models, Constructing Explanations, Engaging in Argument from Evidence, and Using Math/Computational Thinking) appeared very seldom. Most examples of Science Voice were inclusive (either first or second person).

Table 4.1

Exhibit Total Code Frequency.

Code	Subcode	Frequency
Connection	Ethnic Science	7
	Local Science	47
	Science Benefits People	21
	You Try It	25
	Empowerment	3
Discourse	Process	91
	Product	318
NOS	Certainty	4
	Controversial	2
	Curiosity	34
	Evidence	51
	Human Endeavor	47
	Humans and Nature	55
	Impermanent	7
	Improved by Technology	15

Table 4.1 (continued).

	Real-time	16
	Science History/Stories	13
	Nonhuman Work	45
	Revealing	6
Practices	Analyzing/Interpreting Data	20
	Asking Questions	26
	Constructing Explanations	7
	Modeling	7
	Argument	0
	Using Information	0
	Using Math/Computational Thinking	2
	Planning/Carrying Out Investigations	33
	Making Predictions	11
	Collecting Data	60
Voice	First person *inclusive* (plural)	27
	First person *exclusive* (singular and plural)	5
	Second person *inclusive* (singular and plural)	51
	Second/Third person *exclusive* (singular and plural)	18
Use of Language	Analogy	11
	Poetic Science	5

Using the observation protocol (Appendix A), observations of the exhibits were made, and text and images of people were coded and analyzed. Many of the exhibits were reminiscent of Iannini and Pedretti's first and second generation of museum exhibits, for display and didactics (Iannini & Pedretti, 2020). They were text heavy and had few, if any, interactive components. Two exhibits, though, attempted to move beyond that approach, Investigate Health and Hidden No More. These exhibits had many interactive components, yet only the latter made efforts to feature the contributions of those underrepresented in science.

Exhibit Observations and Text Coding

Exhibit: How We Know About the Past

This fossil exhibit (Figure 4.1, A) is located on the third floor of the older part of the museum and is situated between a small display about NC geology and a large section called

Figure 4.1

Map Showing Location of "How We Know About the Past" (A = Fossil exhibit, B = dinosaur exhibit, and C =NC geology).

“Prehistoric North Carolina” focused on dinosaurs (Figure 4.1, B and C). The path through the exhibit is linear with content along one side of the space, beginning with a description of where fossils are found in North Carolina and ending with the entrance to the dinosaur exhibit. The exhibit content appears to be geared toward a general audience, but it is very text-heavy and presented only in English.

Text content contains minimal jargon, and any esoteric words are supported by definitions and/or examples. For example: “Many of the rocks containing fossils metamorphosed (cooked) during the formation of the Appalachian Mountains.” In this segment, the word metamorphosed is parenthetically defined as “cooked.” Most of the text content explains different types of fossils and how they form. There are many displays of authentic fossils, yet there is minimal interactive content. The exhibit contains only one fossil that can be touched (a life-sized reproduction of a T. rex skull, Figure 4.2).

Figure 4.2

Example of Fossil Displays.

One panel has blocks that can be rotated to reveal objects and asks visitors to think about which dating technique they would use. Little content is centered on the science work of paleontologists. Reference is made to only one named paleontologist, Baron Georges Cuvier, a White French nobleman and early 19th century naturalist, referred to here as "the father of paleontology." The majority of images containing people are photos of White male researchers but does show those researchers engaged in data (specimen) collection. There is no attempt to connect content to marginalized groups or nondominant culture or to recognize and redress any bias. Connection to place is evident in the section on North Carolina fossils (See Figure 4.3).

Figure 4.3

Exhibit Example of Connection to Place.

In this fossil exhibit, 102 segments of text were isolated for analysis. The Science Discourse that emerged from coding this exhibit was almost entirely Science as Product as compared to Science as Process (99%). Only one example of Science as Process, referencing researchers' "new discoveries," was coded in this exhibit: "Today, researchers continue to inspire us with new discoveries and theories about the history of life on Earth." This was also the lone reference to Science as Human Endeavor. A typical Science as Product example segment was: "Eastern North Carolina is rich in fossils, especially marine fossils, since at times it was submerged." Science Voice was limited to a few instances (i.e., little use of any personal pronouns like I, you, they) but were mostly inclusive. For example, this segment uses the inclusive first-person *our*: "With analysis, interpretation, and a dash of imagination, fossils and rocks become ***our*** windows on life through time." Most of the exhibit content referred to the fossils and their formation and not the people or their work. NOS: Evidence did emerge many times, for example: "Trace fossils are the many clues left behind by plants and animals— not pieces of actual organisms-that hint at a plant's or animal's existence." There were very few references to any Practices, and this example fails to connect the scientist to the practice: "With analysis, interpretation, and a dash of imagination, fossils and rocks become our windows on life through time."

Figure 4.4

Map Showing Location of "Unraveling DNA" (#24).

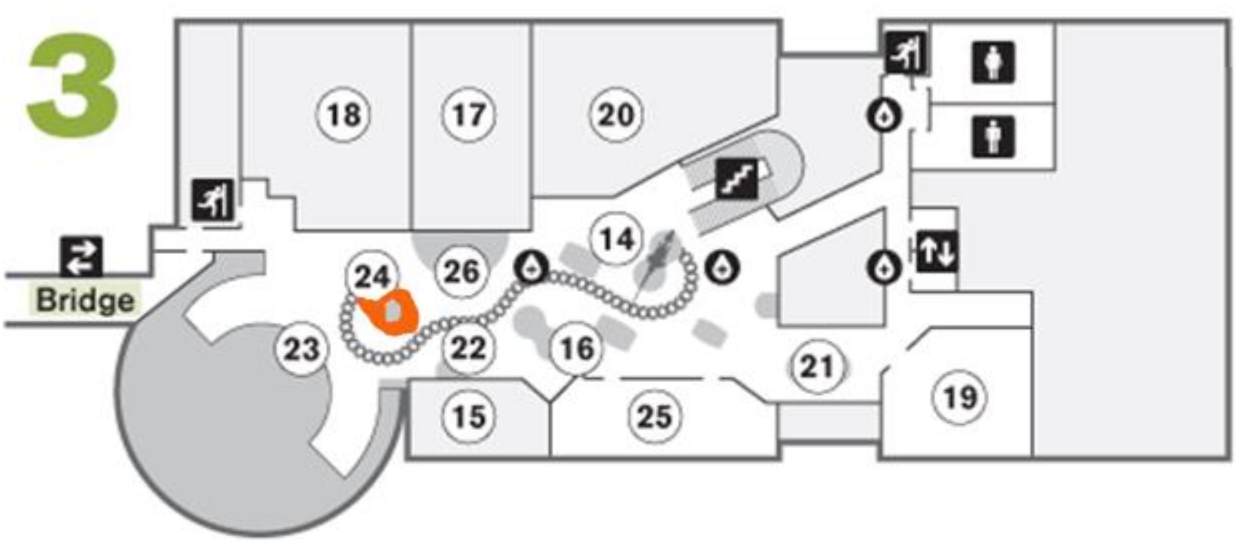


Exhibit: Unraveling DNA

This DNA exhibit (#24 in Figure 4.4) is located on the third floor of the newer part of the museum and is situated between the Evolutionary Biology and Behavior Research Lab (#18) and the Astronomy and Astrophysics Research Lab (#15). The exhibit content is arranged around a center kiosk, and the most logical path around is counterclockwise as the first section in this direction contains an introduction to genetics and important definitions (Figure 4.4).

There are 5 distinct sections: introduction to DNA; research with animal models; DNA research in fish; genetic diversity; and similarities in organism DNA. The target audience for this exhibit appears to be the general public, but, because of vocabulary and abstract concepts, the content would be most appropriate for visitors who have already been introduced to it, maybe middle school age and older. Text contains many esoteric words related to DNA and genetics, but most are well-explained and/or defined. Genome, for example, is defined as the way "molecular biologists use this term to refer to the entire DNA code from a particular organism." Text is presented only in English. Text content is supported by many photos and illustrations, some objects, and one interactive component.

Photos depict a diversity of racial and ethnic groups and a balance of genders. Illustrations, mostly diagrams, visually support the science content but, like text, describe abstract concepts and contain a lot of jargon. There are a few objects (such as a model of a rat) and a tank of live zebra fish used to support a video about research. The one interactive component is a panel that allows visitors to press buttons to compare the percent DNA in common between humans and other animals. There is a strong human connection in this exhibit. Connections are made to human health, including research, diagnosis, and treatment as seen in this segment: "Over 4,000 human diseases can be traced to a single gene mutation." Connections are also made to other human uses of genetics like dog breeding. There is no attempt to connect to marginalized groups, nondominant culture, or local place or to recognize and redress bias.

In this exhibit, 123 segments were isolated for analysis. The Science Discourse that emerged from this exhibit was predominantly Product and not Process. An example of product is statement that "all organisms share some genes." NOS: Science as Human Endeavor did appear many times as the work of geneticists was described: "Genetic engineers used genes from coral and jellyfish to give zebrafish the fluorescent colors you see here. Using data from experiments like these on model organisms like zebrafish, scientists hope to someday cure diseases and lengthen lifespans in humans." This segment is also a good example of Connection: Science Benefits People (the most common Connection subcode) as it describes how the research could be used to cure disease. Subcodes for Practices included many parts of the science process including Asking Questions, Collecting Data, Experimenting, and Analyzing Data. This segment is a good example of Practices: "Now researchers also use similarities in the DNA code to reveal relationships: the more similar the code, the more closely related the species." When Voice was coded, it was equally inclusive (e.g., "In the not-so distant future, knowing your personal genome could be part of a routine checkup.") and exclusive (A molecular biologist loads samples into an automated DNA sequencing machine, similar to the one in our genetics lab."). No other codes were prominent.

Exhibit: Researching Weather

This weather exhibit is located on the second floor of the new section of the museum (Figure 4.5, #9). It is situated in the middle of the floor near the stairway. There are two parts to this exhibit. Nearest the stairs, weather research content is arranged around a central kiosk. Nearby, computer terminals and a large screen allow visitors to sit and work with the interactive component. Visitors can logically move around the kiosk either clockwise or counterclockwise. Visitors can engage with the interactive component, with content not dependent on the rest of the exhibit, before or after the kiosk content.

Figure 4.5

Map Showing Location of "Researching Weather" (# 9).

The target audience appears to be the general public. Text contains some esoteric words related to weather research, but most are well-explained and/or defined and supported by diagrams and objects. Like most exhibits in this museum, text is presented only in English. In addition to text, there are many objects and images that visually support the science content. Images of people depict a diversity of racial and ethnic groups and a balance of genders. There are many objects, including natural objects, like a cross section of a large tree, and tools and instruments used to measure and collect data, such as a weather balloon and rocket.

In addition to the textual content, there are two computer-linked stations where visitors can 1) use historical data from a hurricane that impacted the state to predict its course or 2) use current area data to forecast the weather. The experiential component is introduced by a female meteorologist from a local television station. There is a human connection in this exhibit as people are pictured conducting weather research like launching a weather balloon, but the content predominantly focuses on tools and not on the humans who use the tools. There is a strong local connection in the experiential component described above and in this segment about a bald cypress tree which “began growing in the year 1116 in what is now NC.” There is no attempt to connect to marginalized groups or nondominant culture or to recognize and redress bias.

In the Researching Weather exhibit, 144 segments were isolated for analysis. For Science Discourse, Process (66%) appeared twice as often as Product (34%). Process is demonstrated in this example: “Meteorologists analyze a constant stream of data, with the help of computers, to forecast tomorrow's weather-and to improve our predictions into the future.” This segment is also a great example of NOS: Science as Human Endeavor as it connects the scientist, a meteorologist, to the practices of weather research. An example of Product can be found in this segment: “Bald Cypress can hold a climate record of more than 1,000 years in their rings.” Practices: Collecting data was prominent but other practice subcodes were less common. Collecting Data is found in these segments: “Scientists need ways to monitor conditions higher up in our atmosphere. For that, they use balloons and rockets to carry sensors into the atmosphere.” There were many references to NOS: Science as human endeavor (see example above), but more than twice as many references to non-human science work as in this example in which the work is attributed to the weather station and not the scientist: “Weather stations on land and sea collect reams of data-but all they can sense is weather near the ground.” This exhibit also contained many references to the ways that the science of weather research is improved by technology (NOS: Improved by Technology) as in this segment: “A network of radars constantly scans the skies to detect severe weather and precipitation." This segment also serves as an example of the code NOS: Real-Time. Most of the practices found in this exhibit were coded as Collecting Data such as: "From ground-based stations to satellites, from balloons to ocean buoys, sensors collect weather data." This segment also exemplifies the focus in this exhibit on non-human work (i.e. sensors) rather than the work of scientists. When Voice was coded, it was most likely First Person Inclusive and plural as in this example: "Forecasters use computer models to convert the data into the weather predictions ***we*** rely upon." Other codes were not prominent.

Figure 4.6

Map Showing Location of "Carolina Wildlife".

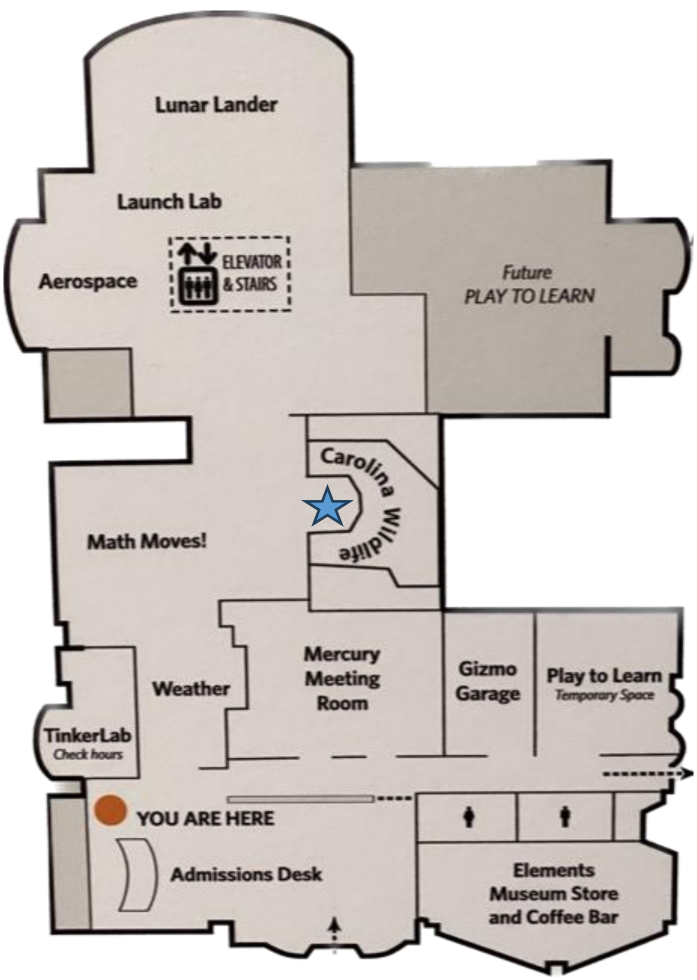


Exhibit: Carolina Wildlife

This live animal exhibit is located on the first floor in the middle of the museum near the Math Moves exhibit (Figure 4.6, marked with a star). Sliding automatic doors separate the exhibit from the surrounding space to create a calmer environment for the animals inside. There is a clear entrance and exit to the exhibit. Upon entering there is a quote from White American 19th century naturalist John Burroughs: “The place to observe nature is where you are.” This quote, as well as all the other text, is in both English and Spanish. The target audience is the general public of all ages, and the text does not contain a lot of jargon or esoteric language. Most of the text describes the animals and their habitats, but one panel describes the ways human development affects wild animals. Live animals in enclosures are arranged on both sides of the semicircular space. . There are about 25 enclosures containing live animals, mostly reptiles, birds, and fish, which are displayed in habitats designed to appear natural (Figure 4.6). There are no visual or textual representations of people in the exhibit. Science is represented as “nature,” and the text conveys the message that humans and animals need to coexist as two connected parts of nature. There are no interactive components within the exhibit, and visitors are meant to travel through a one-way path passing by all of the enclosures. Steps are present in front of exhibits for people who may have difficulty seeing

Science is represented as “nature,” and the text conveys the message that humans and animals need to coexist as two connected parts of the natural world (see below for the Code: Humans/ Nature). The local connection is strong as all the featured animals are from the area. There is no attempt to connect to marginalized groups or nondominant culture or to recognize and redress bias.

In this animal exhibit, 196 segments were isolated for analysis. This exhibit's Science Discourse was focused solely on Product with no references to Process. A typical example is this animal enclosure label: "Tiger salamanders are subterranean, meaning they live underground." Humans were not represented as scientists (i.e., NOS: Science as human endeavor), but instead as organisms who share animal habitats (NOS: Humans/Nature). The panel about kestrel nesting sites explains that "[h]uman-made bird boxes help replace these lost nesting sites." There were also many references to local place as in this description: "If you encounter a large black snake in North Carolina, chances are it's a rat snake." Almost all of the enclosures listed the local range and endangered status in the state. Like other exhibits, the Practice subcode that was most common was Collecting Data like this example: "By examining the nest materials birds use, we can understand the problems a species tries to solve over time."

Figure 4.7

Map showing location of "Investigate Health."

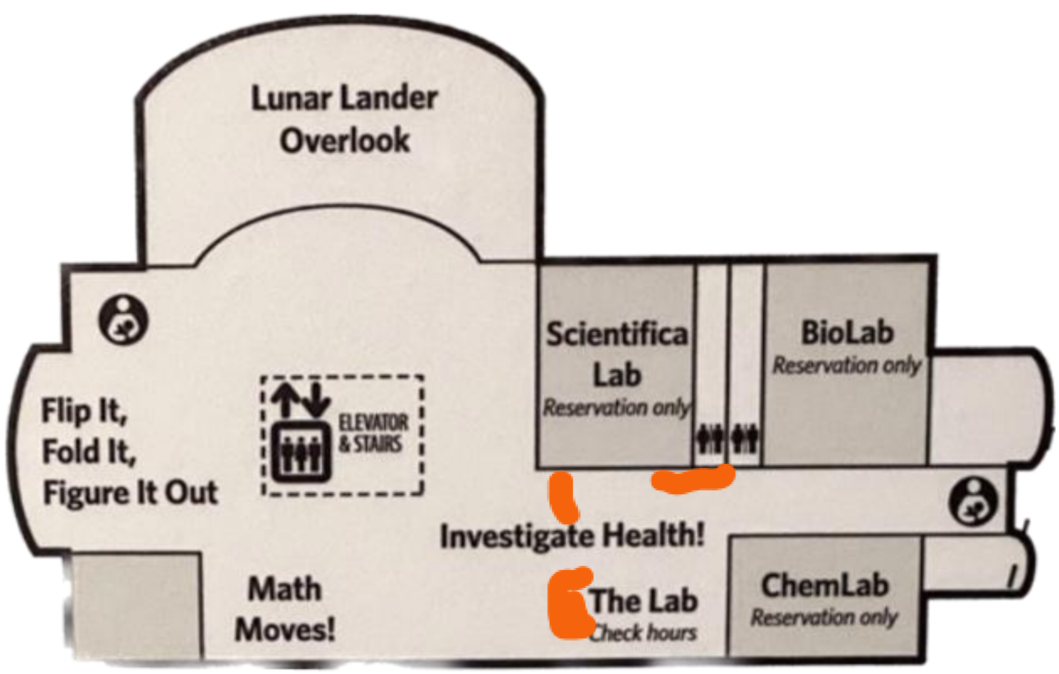


Exhibit: Investigate Health

This human health exhibit is located on the second floor near the labs (which are used for classes) (Figure 4.7). Content is arranged around a central kiosk and along the outside walls on either side of the area, and visitors can engage with the content in any order. There are sections on biofeedback, dust mites and allergies, sunscreen protection, wearing a seatbelt, and handwashing to remove germs. Content is targeted at the general public. All sections described above contain experiential components that can be experienced by all visitors, but some text is written at the upper middle school level and younger children may need adult assistance to understand. Several of the interactive displays allow visitors to conduct an investigation and collect data. For example, to test the effectiveness of their handwashing, visitors apply a lotion that glows under UV light, wash their hands, and finally examine their washed hands under UV light. Photos depict a diversity of racial and ethnic groups and a balance of genders and ages.

While there are no depictions of scientists, the entire exhibit encourages visitors to be the investigator collecting data and making conclusions. There is a strong human connection in this exhibit as the content focuses on human health. There is not a strong local connection in any exhibit component. There is no attempt to connect to marginalized groups or nondominant culture or to recognize and redress bias.

In this human health exhibit, 77 segments were isolated for analysis. While the exhibit is highly interactive, the Science Discourse in the text is mostly Product (91%). An example of the few Process occurrences is the interactive component on handwashing: "Use this glowing lotion to see how well you wash your hands." Typical Product is this example about dust mites: "People who are allergic to dust mites can use special pillowcases and mattress covers made from tightly woven fabrics." Connection subcodes You Try It and Science Benefits People appeared many times. In each interactive component visitors are invited to participate directly in the science like in this example: "Try feeling the bump to the left of the arrow. This bump is about the same size as a dust mite." Science Benefits People is evident in many components like this example in the one on seatbelt safety: "Booster seats can improve the fit of seatbelts dramatically." Practices subcode Collecting Data and Investigating were prevalent. Collecting Data was found in this segment "Use this glowing lotion to see how well you wash your hands," while Investigating was evident in the introductory segment, "Welcome to Investigate HEALTH! where you can test and see for yourself why health experts tell us to buckle our seatbelts, wash our hands, put on our sunscreen, and more." Science Voice was mostly second person inclusive (76%) and often co-occurred with Connections: You Try It: "Change ***your*** body just by changing ***your*** mood."

Exhibit: Hidden No More

This exhibit about light is located on the bottom floor of the museum. It was developed as a temporary installation that can be set up in a variety of locations like libraries and community centers as well as other museums. Because the exhibit can be set up in a variety of ways, there is no specific layout. Content of Hidden No More is targeted for the general public, and experiential aspects can be experienced by all visitors, but some text is written at the upper middle school level and younger children may need adult assistance to understand. Any jargon is well-defined and supported by diagrams and other illustrations. All text is written in both English and Spanish. The science content of this exhibit centers on light, but the exhibit also features the light-related work of underrepresented scientists, Kamal al-Dina al-Farisi and Mercedes Lopez-Morales. Al-Farisi was a 13th century optical experimenter, and present-day scientist Lopez-Morales is described as an exoplanet hunter. Each component of the exhibit is interactive allowing visitors to experiment with light, filters, and the color spectrum. There is also a virtual reality (VR) component where visitors don VR goggles and are immersed in the work of the featured scientists. Currently the exhibit features 2 scientists, but plan exist to expand the exhibit to a total of 6 (3 present-day and 3 historical). The only depictions of people are of the featured underrepresented scientists, but there is a strong human connection in this exhibit as the content focuses on the work of those specific scientists. There is a local connection to one of the featured scientists who completed graduate work at a local university. There is strong connection to marginalized groups and nondominant culture as the exhibit strives to "continually highlight the range of contributors [from underrepresented groups] to STEM fields today and throughout history," and therefore works to recognize and redress bias.

In this light exhibit, 57 segments were isolated for analysis. The Hidden No More exhibit focused on the work of the 2 scientists, and the Science Discourse often referred to their work, with Process (67%) twice as common as Product (33%). Process was coded in the work of the scientists: "He conducted experiments with a model of a raindrop-a water-filled glass sphere." Product was less common as found in this example: "But in blue light, a red object cannot reflect red-it absorbs blue and appears darker." In referring to their work, there were also many instances of NOS: Science as human endeavor and Practices: Carrying out investigations. Science as Human Endeavor was coded in this segment: "By analyzing the colors of starlight filtered through an exoplanet's atmosphere, López-Morales and her team of researchers can determine if it has oxygen or other substances needed to support life." Carrying Out Investigations was identified in the following segment: "Because molecules absorb certain wavelengths in the starlight spectrum, the missing colors will help you detect these building blocks for life" Again, because the text focused on the work of the two scientists, the Voice was often 3rd Person exclusive as in this example: “He conducted experiments with a model of a raindrop-a water-filled glass sphere.” Two subcodes for the code Connection were prominent, Ethnic Science and You Try It. In this segment, the work of al-Farisi was highlighted: “Al-Farisi (1267-1319) was a scientist and mathematician in Tabriz, Persia.” Because most of the components were interactive, You Try It was also seen many times like in this example: “Try It Yourself! Press the different colored buttons to shine colored light onto the Lego bricks.”

Image Coding

Image Coding Summary

Eighty-four images were captured across the 6 science museum exhibits. The images were coded for apparent gender, apparent race, and type of science. These codes were used to support the ways science is represented (i.e., is science re/presented from a particular gendered, racialized, or discursive perspective). Of the 84 images, 4 images were excluded because both race and gender were not apparent (e.g., image showed only hands wearing gloves). After exclusions, a total of 80 images were analyzed (see Table 4.2).

Apparent Gender

Of the 80 images, 46.2% were coded as Female, and 48.8% were coded as Male (Figure 4.7). No images were coded as non-binary, and in 5% gender was coded as not apparent (e.g., a child wearing a bicycle helmet). We can consider the representativeness of these images to several comparison groups (see Table 4.6). By gender, the US population is 50% Male and 50% Female (US Census Bureau, 2019). Compared to the US population, images were approximately representative of gender. In Figure 4.7, the person in the image on the left was coded as male. The people in the image on the right were both coded as female.

Table 4.2

Image Coding Results.

Category	Subcategory	Frequency	Percent of Total
Apparent Gender	Female (Feminine)	37	46.2
	Male (Masculine)	39	48.8
	Not Apparent	4	5
Apparent Race	POC	38	47.5
	White	42	52.5
	Not Apparent	0	0
Type of Science	Professional Science	28	35
	Everyday Science	52	65

Apparent Race

Of the 80 images, 47% were coded as People of Color (POC; Non-white), and 52.5% were coded as White (Figure 4.7). There were not enough images to disaggregate the POC group into subgroups such as Asian, Black, Hispanic, and mixed race. By race, the US population is 65% White and 35% POC (US Census Bureau, 2019). Compared to the US population, images of POC are overrepresented and White people are underrepresented. In Figure 4.8, the person in the image on the left was coded as White. The people in the image on the right were both coded as POC.

Type of Science

Of the 80 images, 35% were coded as Professional Science, and 65% were coded as Everyday Science. All images were coded for type of science. In Figure 4.8, the person in the image on the left was coded as professional science. The people in the image on the right were both coded as everyday science.

Figure 4.8

Examples of coded images of people.

Type of Science by Race and Gender

When type of science is further disaggregated by race and gender, the results are as follows (see Table 4.8). In professional science images, people are depicted in the following percentages: White male 46.43, White female 28.27, POC male 7.14, and POC female 10.71. When compared to racial and gender representation in the US (US Census Bureau, 2019), White males are overrepresented and White females are representative. POC males and females are underrepresented. In everyday science images, people are depicted in the following percentages: White male 19.23, White female 15.38, POC male 26.92, and POC female 34.62. Compared to racial and gender representation in the US (US Census Bureau, 2019), both White males and females are underrepresented. POC males and females are overrepresented.

Representation in professional science images can also be compared to actual STEM and US workforce representation (NCSES, 2023) (Table 4.3). When this comparison is made, White females are overrepresented in images when compared to actual representation in the STEM workforce but not US workforce in general. POC males are underrepresented when compared to both STEM and US forces, and POC females are slightly overrepresented when compared to STEM workforce but underrepresented compared to the US workforce.

Table 4.3

Images by Type, Gender, and Race .

	% Profess. Science	% STEM Workforce**	% US Workforce**	% Everyday Science	% US Population*
White	82.14	70.6	67.2	36.53	59.2
White/Male	46.43	53.8	35.7	19.23	29.6
White/Female	28.57	16.8	31.5	15.38	29.6
White/Unclear	7.14	--	--	1.92	--
POC	17.85	29.4	32.8	63.46	40.8
POC/Male	7.14	21.1	17.2	26.92	20.4
POC/Female	10.71	8.3	15.6	34.62	20.4
POC/Unclear	0	--	--	1.92	--
Male	57.69	74.9	52.9	48	50
Female	42.31	25.1	47.1	52	50

*US Census Bureau, 2019

**NCSES, 2023

Research Question 2: Survey Results

Survey Summary

The intention of the first 2 sections of the survey was to determine how often and why respondents visit science museums and how they feel about belonging and inclusion when there.

Results were disaggregated based on self-reported racial identity. While there were only small differences, if any, for visitation frequency and reasoning between White- and POC-identifying respondents, there were statistically significant differences in perceptions of belonging. Many belonging indicators were significantly lower for POC respondents when compared to White. The final sections asked respondents about how exhibit might affect their perceptions of belonging. For White participants,

Visitation Frequency and Leisure Activities

When asked about leisure time activities, parks and museums were the most popular choices followed closely by shopping and dance (Table 4.4). Concerts/shows, athletics, arcades/funparks, and movie theaters were also somewhat popular choices. Additional activities provided by respondents included restaurants, outdoor spaces other than parks, and creative spaces.

In the survey, respondents were asked how often they visited museums and the reasoning behind their visitation frequency. Only one respondent (<2%) reported never attending a museum in the past year. One fourth of all respondents reported visiting once or less per year, 45% visit between 2 and 5 times a year, and 23% visit more than five times a year. There were some small differences that were not statistically significant in the visitation frequency distribution between the respondents who identified as POC to those who identified as White, and reasons for visiting were similar.

For POC respondents, there was even distribution across the visitation frequency categories. Reasons for low visitation (i.e., one or zero visits per year) were varied and ranged from COVID to preference for outdoor activities. Reasons for moderate to high visitation (2 or more visits per year) focused on family time, fun, and learning.

Table 4.4

Visitation Frequency and Leisure.

Characteristic	Category	Frequency	Percent
Visitation Frequency (# in past year)	No Attendance	1	<2
	1 or fewer	18	25
	2-3	19	27
	4-5	8	11
	5 or more	25	35
Leisure Preferences (respondents could make multiple choices)	Park	48	
	Museum	36	
	Mall/Shop	31	
	Dance	31	
	Concert/Show	20	
	Athletics	17	
	Arcade/Funpark	10	
	Movie Theater	10	
	Outdoor Spaces (not parks)	4	
	Restaurants	2	
	Creative Spaces	1	

For White respondents, the extreme visitation categories (1 or fewer and 5 or more) had the highest counts. Reasons for low visitation tended to be related to interest and suitability (e.g., aimed at kids). Reasons for moderate to high visitation were very similar to POC responses: family time, fun, and learning.

Contextual Learning, Belonging, and Inclusion

In the survey, respondents were asked about their sense of museum belonging, defined as perceptions of belonging in the science museum setting, using items from Price and Applebaum's Cultural Contextual Learning Scale (Price & Applebaum, 2022) and items aligned with Falk and Dierking's Model of Contextual Learning (Falk & Dierking, 2018). Survey respondents were asked to rate 18 statements on a Likert scale (1=strongly disagree to 5=strongly agree) (Table 4.5).

Overall, the average response for all respondents was 4.07, which indicates general agreement with the statements on belonging. White respondents rated most statements on average between 4-5, indicating high levels of agreement. Convenience of hours (M = 3.88) and statements about their presence ($M = 3.82$, $M = 3.45$, $M = 3.30$) were rated on average between 3-4. No statements were rated on average below 3.3 for White respondents. POC respondents rated most statements on average between 3-4.25, indicating neutrality or moderate agreement. Museum content ($M = 2.82$) and guests reflecting their community ($M = 3.00$) were rated the lowest.

Results of the average Likert ratings for Contextual Learning and Belonging items are reported in Table 4.2. There were no statistically significant differences in the ratings between POC and White respondents for most of the Model of Contextual Learning items (e.g., reasonable hours, $t(31) = 0.17$, $p > 0.05$, cost, $t(31) = 0.28$, $p > 0.05$, and location, $t(31) = 0.86$, $p > 0.05$).

Table 4.5

Contextual Learning and Belonging Average Likert Rating.

Statement	All	POC	White
The building was welcoming.	4.34	4.25	4.42
Signs and maps were helpful. **	4.36	4.07	4.61
The exhibits were interesting and relevant to me. *	4.30	4.07	4.48
The programs were interesting and relevant to me.	3.93	3.81	4.03
The staff were friendly and helpful.	4.34	4.21	4.45
Other guests were respectful.	3.97	3.86	4.06
The cost was reasonable for what I got.	4.11	4.07	4.15
The hours of operation were convenient for me.	3.90	3.93	3.88
The museum was easy to get to.	4.26	4.14	4.36
The museum promoted an equal experience for people like me. *	4.09	3.75	4.39
Museum guests reflected my community. **	3.70	3.00	4.30
Museum content reflected my community. **	3.60	2.82	4.27
I felt very comfortable at the Museum as a person of my gender. *	4.70	4.61	4.85
I felt very comfortable at the Museum as a person of my race and/or ethnicity. **	4.50	4.04	4.91
I could be myself there. *	4.60	4.32	4.85
I could help others have a better experience at the Museum.	3.82	3.82	3.82
By being there, I made the Museum a better place.	3.44	3.43	3.45
My presence there mattered.	3.36	3.43	3.30

**$p<0.01$

* $p<0.05$

There were, however, statistically significant differences between groups in many of the Cultural Contextual Learning items (e.g., items related to comfort, community, equality). Of the 18 statements, eight were rated significantly lower by POC than White respondents. Statements with the greatest difference referred to equality of experience, $t(31) = 2.45, p < 0.05$, comfort, $t(31) = 5.22, p < 0.01$, and how well the museum reflected community, $t(31) = 5.51, p < 0.01$. Responses to the statement about the helpfulness of signs and maps was also significantly lower for POC, $t(31) = 2.77, p < 0.01$.

Survey respondents were also asked what community they were thinking of when they responded to the statements in this section. For POC respondents, community most referred to the people belonging to their racial or ethnic group (e.g., Hispanic or Black American) (53%). For White respondents, community most referred to the people who lived in the same geographical area (47%). Other descriptions of community included gender, age, and family structure (e.g., young parents with children).

In addition to the provided statements, respondents were asked 2 open-ended questions about other museum characteristics that increase their sense of belonging and inclusion. Responses from POC and White respondents were similar. These included physical accessibility (e.g., stroller friendly), representation and relevancy (e.g., highlight diverse contributors, native flora/fauna), and diverse and welcoming staff (e.g., staff receptive to questions, more POC staff). Several respondents from both groups reported that there was nothing more museums could do to improve their inclusion and belonging (“everything seems good to me” or “no suggestions based on the science museums I’ve visited”).

There were some differences noted between POC and White respondents. Thirteen POC respondents cited the importance of language accessibility both in staff and signs and printed material, while no White respondents suggested this improvement. Several POC respondents reported belonging and inclusion were predominant concerns while at museums. For example, one POC respondent reported that they “do not let history or attitudes deter [them] from participating” and that for them inclusion and respect were “not at the forefront.” Whereas one White respondent stated that museums should “just have the science” and not be “worried about who observes.”

A/B Messaging

Message Creation

From the codes described above, the researcher chose those conjectured most likely to positively influence inclusion and belonging in the exhibit text readers, especially those from groups racially underrepresented in museums (i.e., POC). Seven sub/codes were chosen to target in the A/B messaging. The chosen target codes were Connection (subcodes You Try It and Science Benefits People), Discourse, Voice, Nature of Science (subcode Science as Human Endeavor), and Practices.

Respondents were presented with 8 pairs of sample texts in an A/B messaging format (Table 4.6). For reporting purposes, A is the original unaltered text, and B is the altered text. For each pair of texts, 1-3 of the target codes were implemented that the researcher hypothesized would increase perceptions of inclusion and belonging. Respondents were asked to rate the texts according to how much each statement made them feel inclusion and belonging on a 5-point Likert scale from not at all to a great deal. Then, respondents were asked to explain their reasoning for their rating.

Table 4.6

A/B Messages Comparison with altered text in bold.

Pair	Original Text Sample (A)	Altered Text Sample (B)
1	Crocodiles and alligators can be mistaken for each other, but there are differences. In the photo above, the American crocodile has a longer, thinner head than the American alligator.	Crocodiles and alligators can be mistaken for each other, but there are differences. ***Look carefully*** at the photos of their heads. ***What do you notice*** about the shape? One of them has a long thin head. That's a crocodile!
2	You can shade your skin with umbrellas, clothing, and even sunscreen. The chemicals in sunscreen provide invisible shade for your skin.	***We can shade our skin*** with umbrellas, clothing, or even ***the shadow of a tree***. We can also use sunscreen which has special chemicals that block the sun's harmful ultraviolet rays ***which can damage the cells of our skin and even possibly cause disease***.
3	Wearing a seatbelt makes survival in a car crash twice as likely. Seatbelts work best when they fit across the chest and shoulders and down low over the hips.	***We're twice as likely*** to survive a car crash if we're buckled up properly. Seat belts work best when they fit across ***our chests and shoulders*** and down low over ***our hips.***

Table 4.6 (continued).

4	Most of these rocks are Precambrian, an age before organisms developed the hard parts that fossilize. However, rare fossils and traces of soft-bodied organisms can sometimes be found.	It is difficult for ***paleontologists*** to find fossils from the Precambrian period. During this time, most animals had soft bodies, so they didn't leave behind many fossils to find. ***Have you ever discovered a fossil?***
5	A Persian scientist named Al-Farisi wondered about how rainbows form. He knew that light and color were connected. When light strikes objects of different colors, some wavelengths are absorbed, and others are reflected.	A Persian scientist named Al-Farisi became curious about a question that had baffled scientists for many years. How are rainbows formed? He ***conducted experiments*** with a model of a raindrop -- a water-filled glass sphere. And he found the answer!
6	The ability to determine the organization of the DNA code sequence has been one of the greatest technological breakthroughs in science.	Sequencing human DNA has helped ***scientists*** diagnose, treat, and even ***cure diseases that affect us such as allergies, cancer, and even the common cold***.
7	What's the weather? It's a critical question, and an immense amount of information is used to answer it every day. A constant stream of data is analyzed by computers to forecast tomorrow's weather and to improve predictions of the future.	What's the weather? It's a really important question, and weather ***scientists work hard*** to answer it every day. ***Meteorologists analyze*** a constant stream of data, ***with the help of computers***, to forecast tomorrow's weather and to improve predictions about ***our future***.

Table 4.6 (continued).

8	Trees put on a ring of new growth every year. If the ring is wide, the average weather was good, and if it's thin, the average weather was cold and dry. Trees are very sensitive recorders of yearly climate.	***Look at the section*** of a tree from the mountains of North Carolina. ***Can you find wide rings?*** They tell ***climatologists*** that the average weather at that time was good. ***What do you think thin rings tell us?*** Trees can give us a lot of ***evidence about climate*** in the past.

Ratings of A/B Messages

Overall, a significantly higher belonging rating was given to altered text compared to the original in 7 out of 8 samples (Pair 1, $t(61) = 4.00, p < 0.01$, Pair 2, $t(61) = 1.61, p > 0.05$, Pair 3, $t(61) = 4.22, p < 0.01$, Pair 4, $t(61) = 3.35, p < 0.01$, Pair 5, $t(61) = 2.22, p < 0.05$, Pair 6, $t(61) = 5.95, p < 0.01$, Pair 7, $t(61) = 4.22, p < 0.01$, Pair 8, $t(61) = 2.65, p < 0.05$) (Table 4.7). When comparing A to B ratings for POC, only 2 pairs were significantly different, pairs 4 and 6. On the other hand, all A/B pairs were significantly different for White respondents. When comparing ratings between POC and White respondents, only 1 pair was significantly different, pair 2, statement A. When the mean rating for the original text was compared to the mean rating for the altered text for POC respondents, there was not a statistically significant difference ($M = 3.08$ for original vs. $M = 3.10$ for altered).

Table 4.7

A/B Messaging, Average Likert Rating.

Pair	Text	All	POC	White
1	A (original)	2.72	2.71	2.73
	B (altered)	3.61	3.43	3.76
2	A	3.36	3.04	2.94
	B	2.98	2.96	3.70
3	A	2.84	3.00	2.70
	B	3.72	3.61	3.82
4	A	2.62	2.75	2.52
	B	3.39	3.50	3.30
5	A	2.85	3.04	2.70
	B	3.36	3.18	3.52
6	A	2.57	2.64	2.52
	B	3. 77	3.71	3.82
7	A	2.52	2.68	2.39
	B	3.39	3.25	3.52
8	A	2.81	3.11	2.58
	B	3.44	3.14	3.70

p<0.05 for circled pairs in red

p<0.01 for circled pairs in green

Reasoning for Ratings

In addition to Likert ratings, respondents were asked to explain their reasoning for rating each pair in an open response (Table 4.8). Across all messaging, respondents varied in their identification of the seven target codes. The code Connection (you try it) was identified as increasing inclusion and belonging each time it was used by both POC and White respondents. The code Connection: science benefits people was identified 2 out of three times by both POC and White respondents. In these two instances, one referred to a specific scientist, and the other was connected to human health. The Discourse: process vs product code was identified by respondents only once and very weakly. The respondent identified the text as encouraging "critical thinking." The NOS: science as human endeavor code was identified by respondents in only about half the text pairs where it was employed. In two pairs it was clearly identified by both White and POC respondents. In one, the narrative described the work of a specific real scientist. In the other, the science work done by computers in one text is clearly differentiated from scientists using computers as a tool to do science work the other text. In the one test of the subcode NOS: based on evidence, it was identified by POC but not White respondents. The code Practices was identified 1 out of 2 times by both groups. "Conducting experiments" was identified, while "analyzing data" was not. As for the Science voice code, each time "we" or "our" was used, respondents identified the theme as increasing inclusion and belonging. The one use of second person inclusive ("you") was identified by White respondents but not POC. One White respondent said they felt the text was "speaking directly to me."

In addition to the targeted codes, respondents identified additional reasons they felt increased inclusion and belonging for each text pair. These reasons were organized into themes. One prominent theme was complexity and style of language. Respondents often identified clear, friendly, and easy-to-understand language as a cause for feelings of inclusion and belonging. Some respondents felt more included when the language was more informative and complex. Another common theme was audience specificity. Many respondents identified simpler engaging language as a positive in inclusion of groups with young members, whereas some respondents felt this same language was "child-like" and talked down to them which decreased their perceptions of inclusion and belonging.

For each pair of texts, a substantial number of respondents (18-29%) rated the texts the same and did not identify a difference (e.g., "they are equivalent to me"). Finally, several respondents reported that they did not believe that science text could contribute to inclusion and belonging (e.g., "Well… I'm not a crocodile or an alligator so I guess I'm not included at all.").

Table 4.8

A/B Message Reasoning.

Pair	Targeted Codes	POC Identified Themes	White Identified Themes
1	Connection: you try it (look, notice)	Active participation Asking questions	Active participation Asking questions
	Science voice: second person inclusive (you)	--	Speaking directly to me Personal pronouns
	Discourse: process vs product (collect data vs facts)	--	--
	Additional identified themes:	Friendly Clear, straightforward	Detailed Clear, objective Audience specific
2	Science voice: first person inclusive (we)	Use of "we"	We vs. You
	Connection: science benefits people	--	--
	Additional identified themes:	Detailed, more informative	Detailed, more informative
3	Science Voice: first person inclusive (we)	Use of first person "we"	Use of "we" more inclusive

Table 4.8 (continued).

	Additional identified themes:	Caring, friendly Easy to understand	Detailed, clear Personal, friendly
4	NOS: science as human endeavor (paleontologists)	--	Science work done by people
	Connection: you try it (question)	Interactional question	Interactive question, includes personal experience
	Additional identified themes:	Informative, complex Understandable Personal, friendly	Detailed explanation Excluded from lack of experience Audience specific
5	NOS: Science as Human Endeavor (he conducted experiments)	People are curious and knowledgeable	Scientist conducted experiments
	Practices: planning and carrying out investigations (conducted experiments)	Using the scientific method	Conducting experiments
	Discourse: process vs product (collect data vs facts)	Using the scientific method	Conducting experiments
	Additional identified themes:	Clear, informative Narrative	Narrative Enthusiasm for science Understandable, concrete Detailed, informative Audience specific
6	Connection: science benefits people (cure diseases)	Relevant to human health	Science work helps people
	NOS: science as human endeavor (scientists)	--	--

Table 4.8 (continued).

	Additional identified themes:	Relevant Informative Clear, interesting	Detailed, accurate Understandable Informative Relevant
7	NOS: science as human endeavor (scientists, meteorologists, with the help of computers)	People vs computer work	Science involves people
	Practices: analyzing and interpreting data (analyze)	--	--
	Science Voice: first person inclusive (our)	Use of "our"	Use of "our"
	Additional identified themes:	Understandable, accessible Informative, succinct	Understandable, accessible Audience specific
8	Connection: you try it (look, can you, what do you think)	Inclusive questioning	Engaging questions
	NOS: science as human endeavor (climatologists)	--	--
	NOS: based on evidence (evidence)	Science work based on evidence	--
	Discourse: process vs product (collect data vs facts)	--	Encourages critical thinking
	Additional identified themes:	Informative, detailed, interesting Friendly, engaging Relevant	Audience specific Local connection

CHAPTER 5: CONCLUSION

Discussion

The purpose of this research was to examine exhibits as a source of exclusion so that they might promote a sense of belonging and inclusion for the community members who visit. Many ISEs were created by and for dominant social groups (White and middle class) and, while they recognize it is important, have made little to no effort to connect to marginalized groups and communities to improve visitor diversity. There were four major findings of this study, two for each research question. As a reminder, the following research questions were addressed by this study:

- RQ1: How is science re/presented in science museums?
  - In exhibit text?
  - In exhibit images of people?
- RQ2: How does the way science is re/presented contribute to perceptions of belonging and inclusion for visitors (current and potential) of science museums?

RQ1: Re/Presentation of Science in Museum Exhibits

In the museum exhibits explored in this study, science was re/presented from a mostly dominant cultural perspective as unbiased canonical truth often disconnected from science process and human endeavor. In exhibit text, this is evident from the high frequency of the code Science as Product and the low frequency of the codes Impermanent and Controversial. Moreover, the appearance of science practices was limited mostly to Collecting Data which paints an incomplete and somewhat simplistic picture of scientific process. These results agree with analogous work done previously in science textbooks in which science is presented mostly as canonical knowledge and less frequently as process (Chiappetta et al.,1993; Irez, 2009;

Agustin, 2021). There is some evidence that the exhibits studied attempt to connect to visitors' prior knowledge and allow for interaction to increase learning (Falk & Storksdieck, 2005; Greenfield, 1995), but these findings are more consistent with the traditional roles of exhibits to display and educate (Pedretti & Iannini, 2020b).

In images, science is re/presented as a professional pursuit dominated by White males. While POC appeared in about half of the images, they were predominantly used to illustrate Everyday Science. These results are also consistent with previous work in science textbooks which found more images of males than females (Akcay et al., 2020). This means that females and POC museum visitors are less likely than males and Whites to see images of themselves as scientists, and this lack of representation can have a demonstrated negative effect on their interest in STEM (Pietri et al., 2021; Chambers, 1983).

For people who are underrepresented in science, science as unbiased canonical knowledge can be alienating in that it can give the impression that science knowledge has already been created, while a re/presentation of science as a process sends the message that science knowledge is still being created, and everyone can participate in that creation. Using a critical lens, these results indicate that for the exhibits studies, there has not been a lot of progress made in disrupting the dominant perspective of science museum exhibits. Additionally, there is little evidence that most of the exhibits, through text or images of people, are making any attempt to connect to marginalized groups or nondominant culture or to recognize and redress any bias.

RQ2: Science Re/Presentation and Perceptions of Belonging

Regarding how the re/presentation of science described above contributes to perceptions of belonging, the results were mixed. Consistent with the work of Falk (1993), POC survey respondents reported statistically significantly lower overall perceptions of belonging. This was especially true when related to relevancy, reflection of community, and both personal comfort and as a person of their race. This is contrary to the findings of Price and Applebaum (2020) who found no significant belonging differences in racial groups. Because Price and Applebaum surveyed only museum visitors, this could be evidence that, consistent with Baumeister and Leary (1995), people who have low perceptions of belonging in museums have sought it elsewhere and therefore were not surveyed. The survey used in this study sampled visitors and nonvisitors. It appeared that other people (both staff and guest) and more tangible aspects of the museum (cost, location, physical building, and hours) had little relationship to belonging. Because many of the POC respondents were Latinx, they did cite the importance of multilingual signs and maps. Interestingly, while POC respondents felt lower perceptions of belonging than their White counterparts, they expressed a belief that their presence mattered and could make the museum a better place.

When measured through A/B messaging, POC perceptions of belonging were not attributable to the way science was re/presented in exhibits. However, for White respondents there was a significant difference in all pairs of statements. In other words, White respondents reported increases in belonging as related to exhibit text, while POC did not. A/B testing is typically used to compare messaging aimed at a target audience for a specific outcome. Because the tested text was specifically altered to increase perceptions of belonging in underrepresented groups (i.e., POC), these results were unexpected. One possible explanation may be that the Latinx respondents, though generally high socioeconomic status (SES) and high educational attainment, were not native English speakers which may have limited their ability to discern the nuances that separated the two text choices.

Limitations

The limitations of this study include those resulting from the chosen approach, sample, data collection methods, and analysis. Qualitative approaches are often limited in their generalizability, but steps will be taken to maximize transferability (see "Reliability"). This phenomenological study described the essence of the phenomenon but did not attempt to demonstrate cause and effect. This study was limited to NC science centers and museums and community participants were limited by recruitment sources and techniques. Because this study asked participants to describe their experiences with equity, inclusion, and belonging, some participants may have been affected by social-desirability bias (SDB) which leads respondents to answer in a manner they think will be viewed more positively by others (Fisher, 1993). Assuring anonymity and confidentiality helped guard against SBD. Analysis (and interpretation) was biased by the author's views on and assumptions about inclusion, equity, and belonging which include the existence of systemic racism and dominant culture exclusion within science museums. The researcher's positionality statement makes these biases and assumptions clear.

Implications

Practical Contributions

The practical implications of this study lie in the results of the exhibit observations. These observations suggest that exhibits use a dominant cultural perspective to science that is often separated from human endeavor. This representation can be alienating to marginalized audiences. Museum exhibit developers and educators can use the observation protocol developed for this study to assess current exhibits and formatively evaluate exhibits under development. Using the results of the observation assessment, museums can work to employ a more humanistic approach in exhibits which presents science as a human endeavor and acknowledges its bias, historical perspective, contemporary contexts, and connections to culture (Klopfer & Aikenhead, 2022) and to shift away from purely pedagogical exhibits and move toward more agential and critical exhibits which can increase empowerment. Moreover, results from the belonging scale suggest that while POC visitors have lower perceptions of belonging, they believe their presence at the museum matters, a result museums can use to connect to POC visitors in targeted programs, advertising, and exhibits.

Theoretical and/or Research Contributions

This study contributes to the growing literature on nonparticipation in museums as informal learning spaces. While the results were mixed, this study begins the examination of what aspects of the museum contribute to or are most responsible for perceptions of belonging. These results suggest several questions worthy of further study. In *what ways* does exhibit text affect perceptions of belonging? What *other factors* within the museum contribute to perceptions of belonging? Focus groups and a more widely distributed survey could be used to 1) gather more nuanced data about exhibit text and perceptions of belonging and 2) examine other factors in the museum that may contribute to perceptions of belonging.

Conclusion

Science museums play an important role in science learning, but, based on demographics, they aren’t achieving that role for all. The problem was viewed from the perspective of the institution (exhibits) or the individual (belonging). This study found that for most exhibits science is re/presented as canonical knowledge, separate from the process of human knowledge creation, a type of science that doesn’t promote inclusion. Furthermore, these results suggest that belonging in science museums is experienced inequitably by White and POC visitors and the cause is complicated and multifaceted. However, there are still ways that we can modify exhibits to meet that challenge. Overall, the way science is re/presented in exhibits influences perceptions of belonging for some visitors but, among the respondents in this study, not those most marginalized.

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APPENDICES

Appendix A: Museum Exhibit Observation Protocol

Location		
Date/Time		
Exhibit Name		
Topic/Description		
Target Audience		
Typology (Pedagogical, Experiential, Critical, Agential, Asset-based, Other?		
Text	Use of jargon or everyday language	
	Languages presented	
	Process or Product focused	
Visual	Who is represented?	
	Science context	
	Science content, esoteric or everyday	
	Process or Product focused	
Interactive Component? (locus of control)		
Racial/Ethnic Representation		
Gender Representation		

Physical Accessibility (Sight, Hearing, Movement, Neurodivergent, Other?)		
Science Representation	Historical perspective?	
	Nature of Science	
	Cultural consideration/responsiveness	
	Human connection to science	
	Connection to Place	
	Real-world*	
Reflect on museum's cultural lens (CRT*)		
Recognize and redress bias in the system (CRT*)		

*Culturally Responsive teaching

Composite "Score" = Belonging

[Insert Pictures]

[Video descriptions]

[Exhibit Map]

Appendix B: Survey Instrument

Introduction

For the purposes of this survey, these terms are defined as follows:

- Equity is fairness.
- Inclusion is feeling welcome.
- Belonging is a sense of being an important part.

Leisure Activities

This section is asking you questions about your leisure time activities including science museums.

Choose all leisure time locations that you visit regularly (at least 4 times per year).

- Arcade/Funpark
- Athletics (play or watch)
- Concert/Show (perform or watch)
- Dance (participate or watch)
- Mall/Shop
- Movie Theater
- Museum
- Park
- Another location (please describe): (open response)

About how often do you go to science museums or centers (as a visitor)?

- I never go to science museums. (1)
- Fewer than 1 time per year. (2)
- 2-3 times per year. (3)
- 4-5 times per year. (4)
- More than 5 times per year. (5)

If (1) or (2):

Why don't you go to science museums or centers more often? (open response)

If (3), (4), or (5):

Why do you go to science museums? (open response)

Belonging/Inclusion

The next two sections contain questions about your feelings of belonging and inclusion at science museums.

For each statement below, think about your most recent trip to a science museum. How much do you agree or disagree with each statement? (5-point Likert scale from Strongly Disagree to Strongly Agree)

- The building was welcoming. (1)
- Signs and maps were helpful. (2)
- The exhibits were interesting and relevant to me. (3)
- The programs (demonstrations, classes, films, etc.) were interesting and relevant to me. (4)
- The staff were friendly and helpful. (5)
- Other guests were respectful. (6)
- The cost was reasonable for what I got. (7)
- The hours of operation were convenient for me. (8)
- The museum was easy to get to. (9)

For each statement below, think about your most recent trip to a science museum. How much do you agree or disagree with each statement? (5-point Likert scale from Strongly Disagree to Strongly Agree)

- The museum promoted an equal experience for people like me. (1)
- Museum guests reflected my community. (2)
- Museum content reflected my community. (3)
- I felt very comfortable at the Museum as a person of my gender. (4)

- I felt very comfortable at the Museum as a person of my race and/or ethnicity. (5)
- I could be myself there. (6)
- I could help others have a better experience at the Museum. (7)
- By being there, I made the Museum a better place. (8)
- My presence there mattered. (9)

What "community" were you thinking about when you answered the questions above? (open response)

Are there other things that you think make you feel inclusion and belonging at science museums? (open response)

What else, if anything, do you think science museums can do to improve your feelings of inclusion and belonging? (open response)

Text Comparison

In the next section, you will be presented with 2 sample texts. Each of the samples are communicating similar information but in slightly different ways. Rate each text according to how much each statement makes you feel included and like you belong. Then explain why you made the choices you did.

There are 8 pairs of sample texts.

Remember that these terms are defined as follows:

- Equity is fairness.
- Inclusion is feeling welcome.
- Belonging is a sense of being an important part.

I'm not asking about how much you understand the science. Instead, I'm asking you to look at the difference in wording.

Pair 1: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- Crocodiles and alligators can be mistaken for each other, but there are differences. In the photo above, the American crocodile has a longer, thinner head than the American alligator. (1)
- Crocodiles and alligators can be mistaken for each other, but there are differences. Look carefully at the photos of their heads. What do you notice about the shape? One of them has a long thin head. That's a crocodile! (2)

For Pair 1, why did you make the choices you did? (open response)

Pair 2: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- We can shade our skin with umbrellas, clothing, or even the shadow of a tree. We can also use sunscreen which has special chemicals that block the sun's harmful ultraviolet rays which can damage the cells of our skin and even possibly cause disease. (1)
- You can shade your skin with umbrellas, clothing, and even sunscreen. The chemicals in sunscreen provide invisible shade for your skin. (2)

For Pair 2, why did you make the choices you did? (open response)

Pair 3: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- Wearing a seatbelt makes survival in a car crash twice as likely. Seatbelts work best when they fit across the chest and shoulders and down low over the hips. (1)
- We're twice as likely to survive a car crash if we're buckled up properly. Seat belts work best when they fit across our chests and shoulders and down low over our hips. (2)

For Pair 3, why did you make the choices you did? (open response)

Pair 4: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- It is difficult for paleontologists to find fossils from the Precambrian period. During this time, most animals had soft bodies, so they didn't leave behind many fossils to find. Have you ever discovered a fossil? (1)
- Most of these rocks are Precambrian, an age before organisms developed the hard parts that fossilize. However, rare fossils and traces of soft-bodied organisms can sometimes be found. (2)

For Pair 4, why did you make the choices you did? (open response)

Pair 5: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- A Persian scientist named Al-Farisi became curious about a question that had baffled scientists for many years. How are rainbows formed? He conducted experiments with a model of a raindrop -- a water-filled glass sphere. And he found the answer! (1)
- A Persian scientist named Al-Farisi wondered about how rainbows form. He knew that light and color were connected. When light strikes objects of different colors, some wavelengths are absorbed, and others are reflected. (2)

For Pair 5, why did you make the choices you did? (open response)

Pair 6: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- The ability to determine the organization of the DNA code sequence has been one of the greatest technological breakthroughs in science. (1)

- Sequencing human DNA has helped scientists diagnose, treat, and even cure diseases that affect us such as allergies, cancer, and even the common cold. (2)

For Pair 6, why did you make the choices you did? (open response)

Pair 7: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- What's the weather? It's a really important question, and weather scientists work hard to answer it every day. Meteorologists analyze a constant stream of data, with the help of computers, to forecast tomorrow's weather and to improve predictions about our future. (1)
- What's the weather? It's a critical question, and an immense amount of information is used to answer it every day. A constant stream of data is analyzed by computers to forecast tomorrow's weather and to improve predictions of the future. (2)

For Pair 7, why did you make the choices you did? (open response)

Pair 8: If you saw this text at a science museum, how much do you think each statement makes you feel included and like you belong? (5-point Likert scale from Not At All to A Great Deal)

- Look at the section of a tree from the mountains of North Carolina. Can you find wide rings? They tell climatologists that the average weather at that time was good. What do you think thin rings tell us? Trees can give us a lot of evidence about climate in the past. (1)
- Trees put on a ring of new growth every year. If the ring is wide, the average weather was good, and if it's thin, the average weather was cold and dry. Trees are very sensitive recorders of yearly climate. (2)

For Pair 8, why did you make the choices you did? (open response)

Demographics

Please provide the information below about yourself.

Name (optional): (open response)

Age: (open response)

Race/Ethnicity (choose all that apply):

- Black or African American (1)
- Latinx or Hispanic (2)
- White (3)
- Asian (4)
- Another Race/Ethnicity (please describe) or No Answer: (open response)

Gender:

- Female (1)
- Male (2)
- Another Gender (please describe) or No Answer: (open response)

Income What is your household income?

- Under $25,000 (1)
- $25,000-$34,000 (2)
- $35,000-$49,000 (3)
- $50,000-$74,000 (4)
- $75,000-$99,000 (5)
- $100,000-149,000 (6)
- $150,000-$199,000 (7)
- Over $200,000 (8)
- Prefer not to answer. (9)

How would you describe the area in which you live?

- Urban (1)
- Suburban (2)
- Rural (3)
- Mixed (4)
- Another area (please describe) or No Answer: (open response)

What state do you live in? (Drop Down: Alabama ... Wyoming)

How would you best describe your education experience?

- High School or some college (1)
- Associate's Degree (2)
- Bachelor's Degree (3)
- Post-graduate Degree (4)
- Another form of education (describe): (open response)

How would you best describe your work's relationship to science?

- Formal science educator. (1)
- Informal science educator. (2)
- General educator. (3)
- Another science-related profession. (4)
- My work is not related to science. (5)

Is there anything else about science museums or yourself you'd like to share with me that I haven't asked? (open response)

Would you be willing to be interviewed about your responses?

- Yes, please. Add your email below. (open response)
- No, thanks