Interpretation of Visible Labs: The Benefits and Drawbacks

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Abstract

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Natural history museums (NHMs) face a conundrum: they appeal broadly to audiences yet struggle to compete with other informal science venues such as science centers, aquariums, zoos, and botanical gardens (Steiner & Crowley, 2013). NHMs are unique in that they hold collections, and many are also sites of active research. More recently, some of these NHMs have begun to showcase their research to the public via visible lab spaces. These attributes can position NHMs as distinctive sites for public engagement. Despite their potential, relatively few studies have examined the unique role of visible labs in informal learning venues such as NHMS. This study investigated the interpretative strategies used within visible labs and examined how these strategies aligned with educational frameworks. A case study approach including interviews with museum professionals engaged in interpretive planning and interpretation for visible labs and supplemented with document analysis was employed. Findings show that the unique features of visible labs include the process of science as a learning outcome, the demystification of scientists and science, and personalization and connection between the public and scientists. However, to leverage these benefits, scientists in visible labs need more support and validation. These findings demonstrate that visible labs are a unique resource for NHMs, adding to their value and separating them from other informal science venues.

Introduction

A child stands in front of the skull of a massive prehistoric animal. They gaze upon its massive jaw and teeth, amazed to learn this creature once roamed the earth. The halls of a natural history museum capture the feeling of the sublime. A unique emotion of grandeur and wonder. However, the focus on Earth's prehistory inadvertently conveys that NHMs are similarly dated. For many visitors this is underscored by the interpretation of the exhibits, which can range from didactic and jargon-heavy to absent.

Indeed, museum professionals themselves who work at NHMs feel that their institutions are out of touch (Beehler, 2010; Steiner & Crowley, 2013; Wallace, 2005; Watson & Werb, 2013). At the Twenty-first Century Learning in Natural History Settings conference, curators, educators, evaluators, and researchers gathered to discuss the future of NHMs and the various problems plaguing the field, including the role of scientific research in these institutions, the rise of zoos, aquariums, and botanical gardens, and the struggle to hold onto traditional audiences (Hammerness et al., 2016; Kramer & Havens, 2015; Poo et al., 2022; Steiner & Crowley, 2013). A key claim from this conference was NHMs are at a turning point in their history, where they must adapt to remain relevant. These professionals discussed how to shift NHM's traditionally didactic approach to a more visitor-centered model with the main takeaway being that NHMs need to center visitors using a range of interpretive strategies, including promoting personal choices, making science more region-specific, and identifying NHMs' role within the informal science ecosystem (Steiner & Crowley, 2013). Identifying NHMs role within the informal science education venue is what this research aims to contribute to, specifically, by investigating visible labs. Visible labs are a unique facet of NHMs that demonstrate research performed by museums in a visible and accessible format. They are usually within exhibits and present a live demonstration of science through glass windows; however, research into these areas have rarely

investigated the strategies used to engage visitors. Nor has research looked into the educational outcomes and goals of these spaces or what educational frameworks are used to support interpretation. Thus, the purpose of this research is to investigate the interpretive strategies of visible labs in NHMs through educational frameworks.

Interpretation in NHMs

Interpretation is defined as "a narrative and a method of communicating to and with visitors" (Anderson et al., 2017, p. 89) Interpretation can be seen as a language, a bridge, and a cultural experience that aims to convey the museum's values and knowledge to visitors. Interpretation is a wide range of things, but some basic examples include labels, audio-visual elements, and interactives. Essentially, anything within a museum or exhibit that aims to engage visitors with the material presented whether that be though reading, listening, viewing, or touching. Interpretation has often been criticized for being didactic, and as a result there is a growing trend to move towards a more conversational tone that allows visitors to engage with their lived experiences and narratives (Anderson et al., 2017; Bennett, 2013; Robinson, 2020; Witcomb, 2002).

Historically, NHMs change interpretive approaches slowly. A common interpretive style displays 'specimens' behind glass with jargon-heavy labels, often featuring scientific terminology like taxonomic names. These labels typically include a biological or geographical classification and present the 'specimen' as a representative for their species rather than an individual object (Alberti, 2005; Carnall et al., 2013; Grey et al., 2006).

NHM professionals have been reimagining interpretation, with some NHMs adopting more interactive, visitor-centered strategies. For example, Carnall et al. (2013) examined the efficacy of 'social interpretation,' which allows visitors to be co-producers of the exhibits. Some museums have leveraged contemporary issues to engage visitors in a participatory and dialogic experience to break from the traditional, authoritative, and apolitical convention. For example, the Grant Museum's Qrator project uses integrated QR codes within exhibits and invites visitors to engage with labels that raise hard-hitting and complex questions. An evaluation of this project found that 33% of visitors actively engaged with the QR codes, shifting the visitor experience from passive to participatory. Additionally, the project showed how specimens can represent broader themes that encourage discussions, rather than simply serving as an archetype. The study found that social interpretation allowed visitors to actively engage with questions as opposed to the more common static visits. However, it was unclear to what extent visitors recognized their responses would influence the interpretation of the museums' collections. (Carnall et al., 2013, pp. 63–67). NHMs push to adopt innovative strategies mark an interesting chapter in their evolution.

Visible Labs in NHMs

Beginning in the early 2000s, some NHMs attempted to revitalize their institutions by implementing visible lab spaces (Anderson et al., 2017; Brusius & Singh, 2018; Wylie, 2020). Visible labs are research spaces designed with walls of windows, allowing visitors to view lab areas to watch scientists conduct cutting-edge research. In some instances, scientists can directly communicate with the public, or docents will talk with observers. These visible labs are seen as a unique resource that allows the public to view, discuss, or in some cases perform in scientific

research. Visible labs also allow visitors to interact with the on-going research performed by museums (Ames, 1992; Gallimore & Wilkinson, 2019; Hennes, 2007). Likewise, general visible storage spaces, such as collection areas, have also gained popularity in recent years as museums aim to increase transparency and accessibility. By opening these spaces, visitors can deepen their understanding of NHMs as an institution. Visible spaces are held up as a novel strategy for visitor engagement to bring awareness to the swath of collections and the research performed in NHMs.

In a summative evaluation of FossiLab at the National Natural History Museum, visitors in a timing and tracking study appeared highly engaged with the fossil lab. 52% of visitors stopped to view the space with a median dwell time of 36 seconds. (RK&A, 2022, p. 25) Another summative evaluation performed on the *Labs in Life* Exhibit at the COSI museum investigated what connections people made between the activities in the exhibit and the research being conducted in the lab. They found that 69% of participants were aware of the research occurring in the lab, but visitors found it hard to understand the focus of these labs. (ILI, 2011, 9) However, despite the growing institutional popularity of visible spaces, research has primarily focused on visible storage areas rather than visible labs.

A study by Justine Lopez (2016) investigated how visible labs were operated and managed. Lopez found that visible labs serve multiple roles, including exposing the public to active research, contributing to academic disciplines, and breaking down the barrier between science and society by inviting the public to learn more about the scientific process (Lopez, 2016, pp. 22–23) To communicate with the public, labs often rely on technology, such as iPads and TVs, as well as text panels, display tables, posters, and whiteboards (Lopez, 2016, pp. 34–35). Despite these efforts, Lopez's study showed that visitors may not fully comprehend the

purpose of these spaces and sometimes “visitors thought the staff were just actors pretending to do science” (Lopez, 2016, p. 36). Since Lopez’s work in 2016, additional visible labs have emerged across the country and existing labs have revisited their interpretation strategies. Presenting an opportunity to see if or how these lab spaces have changed to increase visitor engagement and address misconceptions about these spaces.

Research by Caitlin Wylie (2020) using interviews with visitors and visible lab staff at six different NHMs paleontology labs found that visible labs do not destroy the black box around how science is done but enclose it in a glass box, making the processes visible but not necessarily comprehensible (Wylie, 2020, pp. 623). Science to non-scientists can be perceived as a black box. This means that nature goes “into” science and out comes knowledge. However, the process of how this happens is not apparent to non-scientists. Wylie’s findings argue that visible labs allowed visitors to glance into these “black boxes” and see the active work of science, figuratively and literally, making it transparent. However, their understanding of what was occurring was limited due to the sparse amount of interpretive material or a limited ability to speak with staff. (Wylie, 2020, pp. 619–632).

A study done by Sarah Dickinson (2020) investigated the emotional impact on museum staff working within visible labs. While the study was impacted by the COVID-19 pandemic, Dickinson still discovered that staff generally felt excited about engaging visitors, particularly children, and found pride in knowing their work was making a visible difference. Conversely, some negative impacts were feeling emotionally drained, heightened feelings from being observed, and increased job responsibilities. (Dickinson, 2020).

A key element that separates visible labs from other areas of the museum is the interaction with scientists. People tend to view scientists and research as a monolith, but visible

labs challenge that idea and force visitors to confront their assumptions regarding science. Studies have shown that bringing the public and scientists together humanizes science and its practitioners (Chittenden et al., 2004; Storksdieck et al., 2005). These studies also showed that participating scientists desired more preparation and training in science communication before they engaged with general audiences. In response to this need, one of the efforts, Portal to the Public, aimed to create a replicable and low-cost science program appropriate for all museums along with an opportunity for scientists trained in science communication to share their work with the public (Selvakumar & Storksdieck, 2013, p. 3). This programmatic effort allowed scientists to improve their communication skills, allowed science museums to engage their audiences in a unique way, and allowed visitors to physically interact with scientists and the STEM field while challenging commonly held perceptions of scientists and science (Selvakumar & Storksdieck, 2013, pp. 8–9). Despite this program not occurring within a visible lab, it highlights the importance of interaction between these two groups.

Regardless of the significant amount of work on how people learn within informal environments and how to bring current research to public audiences, there have been few studies on how this translates into visible lab spaces.

Science Learning Frameworks

A major outcome for informal learning venues is science education; however, the challenge is how to teach these difficult concepts in a free-choice learning environment. In *Learning Science in Informal Environments*, the authors highlight the lack of a unified framework for science education within informal settings and propose their own ‘strands of science learning’ framework. The strands of science framework “articulates science-specific

capabilities supported by informal environments" (National Research Council Staff, 2009). Strand 1 urges museums to create experiences that encapsulate excitement, interest, and motivation to learn about the natural and physical world. Strand 2 is about understanding theoretical frameworks, concepts, and explanations related to science. Strand 3 is understanding how scientific facts are tested and generated. Strand 4 is focused on explaining how science is one of many ways of knowing. Strand 5 is about participating in scientific activities and engaging with scientific jargon and tools. Finally, Strand 6 emphasizes the need for people to be able to view themselves as science learners and, possibly, contributors to the field " (National Research Council Staff, 2009).

The nature of science (NOS) framework was utilized in the creation of these strands for science learning, specifically strand 4. (NRC, 2009, p. 69) The term NOS is defined as "to represent the broad issues related to an understanding of the rules of the 'game' of science, its tools, products, and methods as they apply in educational settings" (McComas, 2017, p. 71). The nature of science (NOS) is a contested idea between historians, philosophers, sociologists, and educators of science; however, it is agreed that it should be taught (McComas, 2017; Osborne et al., 2003). Its contested nature is due to what aspects of science should be presented and to what extent they should be represented. Despite the varying degrees of what should be taught more in-depth, like the role of evidence or the scientific method, experts in the field agree that a baseline understanding of "the rules of science" is critical. Science educators, historians, philosophers, sociologists, and scientists collaborated to formalize the most essential elements of the NOS, selecting nine major themes that were deemed important for science curriculum (Osborne et al., 2003, p. 692). The highest-rated themes were the scientific method, with the highest priorities being, collaboration, and scientific certainty. Collaboration refers to science being peer-reviewed

and a communal activity, while scientific certainty highlights the tentative aspects of science. Other themes included creativity, the historical development of scientific knowledge, questioning, diversity of scientific thinking, analysis and interpretation of data, and finally, hypothesis and prediction (Osborne et al., 2003, pp. 706–709).

To understand the application of NOS in informal settings, Pshenichny-Mamo and Tsybulsky (2023) explored how tour guides at NHMs incorporate scientific knowledge and narratives into their tours, making the information accessible to visitors. The researchers examined how the tours touched on various aspects of the NOS through interviews with tour guides. They found that guides integrated NOS through three main avenues: mentions of general scientific research, references to the museum's research, and remarks on scientific research within exhibits (Pshenichny-Mamo & Tsybulsky, 2023, p. 8). The guides frequently referenced ongoing research and linked it to current exhibits, demonstrating the processes scientists use and how they come to conclusions. Guides framed science as a human endeavor and would tell stories that connected the visitor, research, and the museum's collections all together. (Pshenichny-Mamo & Tsybulsky, 2023, p. 11). These findings are significant for research on visible lab interpretation, as they suggest NOS appears coincidentally within NHMs (Pshenichny-Mamo & Tsybulsky, 2023, pp. 8–13).

Knowing the educational frameworks employed by museum staff in their interpretive decisions is essential for fostering more nuanced, inclusive, and accurate public understandings of science. By better understanding the motivation, reasoning, and desired outcome for visible labs, museums can better cultivate this unique experience for visitors.

The purpose of this study is to investigate the interpretative strategies regarding visible lab spaces in NHMs through educational frameworks. My research was guided by the following questions:

1. What are the motivations for visible labs in natural history museums?
2. What interpretative strategies are used to engage visitors around visible labs?
3. How does the interpretation of visible labs align with educational frameworks?
4. What are the benefits and barriers of interpreting visible lab spaces?

Methods

This research utilized a case study approach to explore how NHMs throughout the United States are using interpretation strategies in visible lab spaces.

Site 1. Denver Museum of Natural Sciences

The Denver Museum of Natural Sciences (DMNS) focuses on six scientific disciplines, anthropology, geology, health science, paleontology, space science, and zoology and has multiple visible labs. DMNS is a Smithsonian affiliate and hosted over 2 million visitors in 2023. Most of the visible labs are paleontology labs, including the Schlessman Family Laboratory of Earth Sciences, which opened in April 1990. Another paleontology lab was recently added for a temporary exhibit, Teen Rex. This prep lab was used to prepare, preserve, and study the findings of a rare adolescent T. rex fossil. The other lab type within this museum is a genomics lab found in the Expedition Health exhibit.

Site 2. Burke Museum of Natural History and Culture

The Burke Museum of Natural History and Culture is an innovative museum that utilizes visible storage and labs on every level. The Burke contains over 16 million artifacts and specimens from their contemporary culture, art, biology, paleontology, and archeology disciplines. From the first floor to the third, visitors can peer into the spaces where researchers, students, and other museum staff members perform their duties. For this study, the two visible labs that are relevant are their biology collections and prep lab along with their paleontology collections and prep lab. The “new” Burke Museum, which utilizes this “inside-out” model, opened in October 2019.

Site 3. North Carolina Museum of Natural Sciences

The North Carolina Museum of Natural Sciences (NCMNS) hosted 617,375 visitors in 2022. NCMNS permanent exhibits include biology, geology, paleontology, and a butterfly room. NCMNS opened their Nature Research Center (NRC) in April 2012. The NRC hosts many different research labs, including astronomy & astrophysics, biodiversity, evolutionary biology, genomics, paleontology, and a veterinary medicine window. The wide variety of labs hosts a unique insight into the different interpretive strategies this museum must utilize to engage visitors.

Data collection occurred through one-hour semi-structured interviews. Interviews were conducted with a range of museum professionals; however, the common theme amongst interviewees was their role concerning visible lab interpretation. All interviews were conducted virtually via Zoom. Where appropriate, document analysis was used to examine the themes that emerged from the interviews. Specifically, the museum's mission statements, interpretative materials, past evaluation studies, and websites were examined to develop a more comprehensive understanding of each site.

Sampling

The institutions examined for this case study were intentionally selected due to specific requirements, such as being a state's natural history museum and containing visible labs. All museum professionals interviewed were involved with the interpretation of lab space. A researcher, an interpretation staff member, two exhibit designers, and one individual that wished to keep their institution and position anonymous were interviewed.

Analysis Procedures

All interviews were recorded on Zoom and transcribed in Word. Word-generated transcripts were then rechecked for accuracy. Minor edits were made to remove filler words and improve clarity. Interview responses were then emergently coded to reveal major themes regarding visible lab interpretation.

Results

RQ1. Motivation

Alignment with the Institution's Mission

A major finding from this research was that all sites described their visible labs with key phrases that aligned with their mission statement, specifically drawing attention to being places of inspiration. For example, one mission statement is "The Burke Museum cares for and shares natural and cultural collections so all people can learn, be inspired, generate knowledge, feel joy, and heal" when asked how their labs align with their mission the staff member answered, "I think it provides opportunities for learning and inspiration." Next, the North Carolina Museum of Natural Science's (NCMNS) mission statement is "To illuminate the natural world and inspire its conservation." When discussing their visible labs staff members said, "A major purpose is to inspire interest and engagement with the sciences". Finally, the Denver Museum of Nature and Science's (DMNS) mission statement is "Be a catalyst! Ignite our community's passion for nature and science." A researcher for this museum stated that visible labs give people "that initial spark for people to consider science and pursuing science." It appears that visible labs are a natural extension of their institution's mission but through a different modality than the typical exhibits.

Visibility and Accessibility

These labs also served other purposes, such as highlighting the museum's collections and their role as a research organization. The Burke sees visible labs as a vehicle to inspire people either through their collections or research. "People had no idea how many things we have in our care… It was always this, like, incredibly special, inspirational, transformative experience for those." Museum staff described NCMNS's purpose of implementing these labs as "to encourage

interest in the sciences and engagement in the sciences, especially among populations that historically might not be engaged in the sciences or might be underrepresented in sciences." This theme might be particularly relevant to the museum's role as the state's natural history museum, "We are free to the public and with that comes a certain responsibility… to serve the people of North Carolina." Similarly, the Burke, which is a part of the University of Washington's campus, felt it had a role in demonstrating not only the possible avenues as a researcher but people attending higher education in general, "maybe [they] see someone at college that they identify with and maybe they have a different perspective of possibilities for their future education."

Peer Institutions

Visible labs at peer institutions are a source of inspiration. All sites named other institutions and museums as inspiration for their labs in the field. DMNS named the Smithsonian National Museum of Natural History and North Carolina's Natural History Museum. The Burke similarly mentioned North Carolina, along with the La Brea Tar Pits and the Exploratorium. Finally, NCMNS also mentioned the La Brea Tar Pits and how, during the development of their spaces, the Burke served as a reference. Despite the Burke opening in 2019, they pilot tested visible labs in their previous location. This would account for how NCMNS, which opened seven years earlier than Burke, would have been able to reference Burke's findings and open before them.

RQ 2. Interpretive Strategies

Early Interpretation Needed Changes

For all sites, initial interpretive strategies needed modifications after public engagement. The need for alterations was due to these sites pioneering these labs and not having many resources or models to follow, as shown by this quote from staff at the Burke, “We certainly looked at any references that were out there. I think there really were very few and none that were holistic… there really weren't whole museum models.” This is particularly relevant to the Burke as their entire museum consists of visible labs and storage. But it also speaks to a more general sentiment of the lack of available resources and models for these museums to follow. Interpretative modifications were informed by formal and informal evaluation leading to a refinement of interpretation strategies across all sites. All three sites have access to evaluation support, but the Burke and NCMNS explicitly called out having used evaluation to research their interpretation strategies. NCMNS used an in-house team and external contractors while the Burke utilized an external evaluation. DMNS described their organization as having internal evaluation capacity, but it is not usually applied to their department. Thus, it is unclear to what extent these sites utilize evaluation consistently and meaningfully for visible labs. Other ways NHMs conduct evaluative research are through staff observations.

During early stages of interpretation, there appears to have been a struggle to find the right amount of information for visitors. Sites varied in their approach in finding the balance between minimal information to allow visitors to explore on their own (DMNS) and oversaturating visitors with information (Burke). DMNS described their early strategies as having some monitors with a video; however, this impact was unclear: “I'm still not sure it provided any context.” Whereas the Burke chose a more hands-on interpretation strategy, but they found guests tended to ignore the interactives and labels: “We actually found that folks would engage with that, but oftentimes they were kind of reaching past it because they just

wanted to be closer to what was happening." Finally, NCMNS placed these labs within exhibits respective to their science. Despite this framing, visitors appeared confused about the labs. "The logic is that visitors would see the DNA-related exhibits… then they would see the Genomics lab and they would make the connection… They didn't make that leap very well."

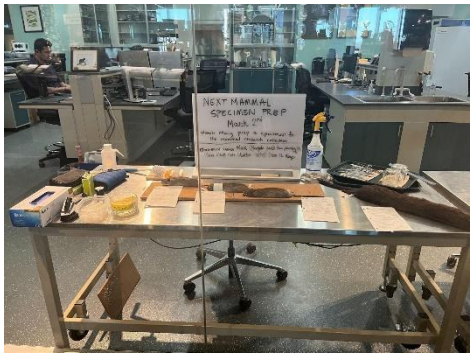
Current Interpretation Strategies

All sites modified their engagement tactics and currently utilize a range of interpretive strategies. A common theme from all these sites was the use of whiteboards. Common themes about these whiteboards include being behind the windows, being written by researchers, and including quick information about the specimens. One interviewee noted that their whiteboards use a framework regarding interpretation: "What, where, and when? So, what is it?... Where was it discovered... When was it [around]."

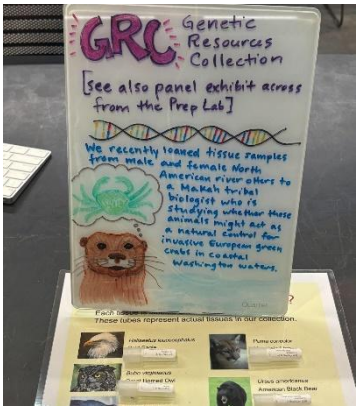
Other than whiteboards, there are a few interpretation strategies observed across all sites, which include windows so that researchers could discuss with visitors or docents, TVs or monitors that displayed videos or PowerPoints, microphones and speakers, and least common, typical labels. Despite minimal crossover appearing between labs, professionals in these spaces seem to be inspired by other institutions' strategies, as shown by DMNS's researchers using whiteboards after visiting NCMNS.

Researcher Autonomy and Confidence

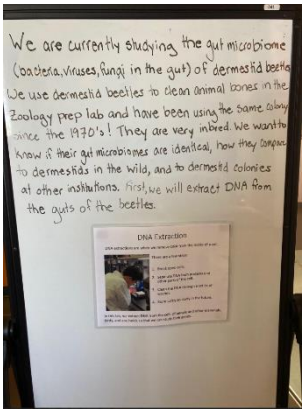
Researchers' whiteboards provide an excellent example of the sense of autonomy and empowerment felt by visible lab staff to initiate and implement their own interpretive strategies.



NCMNS



Burke



DMNS

Decisions on interpretation in labs are dependent on the institution. Notably, these whiteboards are a source of tension between researchers and design staff. As seen from the interpretation staff at NCMNS, “The scientists put in their own whiteboards… And I have to admit, it was a bit of a clash between us over who was in control of that interpretation”. A DMNS researcher provides the other perspective, “I went to North Carolina, and they have a genetics lab, and they had whiteboards at that time, and so I really liked that they had up to date…stuff of what they were working on.” One reason researchers may have an affinity for whiteboards is elaborated further by this DMNS researcher.

> We have pretty much driven any interpretation that is there… I have found that it's better for me just to put something up than it is for me to go through all the common museum channels for that, because everything spirals bigger… until it becomes unfeasible.

However, interpretation staff at NCMNS see the relationship differently: “Yeah, [researchers are] the subject matter experts and we're the interpretation experts.”

Fan Favorite Sciences

Tangible, collections-based fields of scientific research better lend themselves to visible lab interpretation compared to other sciences. During conversations a recurring issue was that

sciences that are not tangible, astronomy and genetics, are much harder to engage visitors with than, say, paleontology. A researcher from DMNS explained it as such: “There’s so much to [genomics], but you know it's like, okay, the neck bones are connected to the spinal cord. You know, like it's a little more self-explanatory.” When discussing the challenges of interpreting different spaces, exhibit staff from NCMNS said this, “I think certain sciences also just lend themselves to visitors.”

RQ 3 Educational Frameworks

Alignment with LSIE Strand One

All three host sites each mentioned inspiration or curiosity when discussing what they hoped visitors would take away. Below are the various quotes:

“I want to be able to share my passion and ignite, their passion and, more, their curiosity…”

“Curiosity and inspiration is a huge one... a sense of connection, whether that's to the natural world, cultural world, to other people, to their own life experiences.” (Burke)

“A major purpose is to also inspire interest and engagement with the sciences... I think inspiring the next generation of scientists has definitely become one of our big goals and outcome.” (NCMNS)

Similarly, during the Burkes’ prototyping of their inside-out visible lab model, their evaluation efforts found that visitors typically described the exhibits as exciting and educational, with one visitor saying “With a person there, it becomes engaging and flexible. It does slow down the research, but the public needs to get engaged with the world.” The NCMNS also did an evaluation of three exhibits and programs pertaining to their visible labs. They found that, specifically with the live animal programs and exhibits, “Children were curious and comfortable

asking the facilitators questions during the Windows on Animal Health program." These findings align with strand one from the NRC's *Learning Science in Informal Environments.*

Processes of Science

A broad trend for lab interpretation is a move away from strict findings of science to a bigger picture of the processes of science. When discussing new interpretive methods with the Burke, a major reason why they shifted their interpretation was to better align with their new learning outcomes.

> We try to unpack some of the statements or the conclusions that we share about science… We try to kind of show the process... It's based on so many building blocks and our museum is full of those building blocks with our collections.

All host sites mentioned aiming to teach, specifically the scientific method, as said here by NCMNS, "One of the major learning outcomes that we want to make sure that visitors walk away with is an understanding of the scientific method." An evaluation report from the NCMNS found that a video outside the astronomy lab was particularly effective in communicating that "scientific research is constantly expanding and changing, and scientists continue to discover new things." This is prominent because two of the most important themes to teach for science comprehension, according to Osborne's study, is the scientific method and the provisional nature of science.

Challenging Assumptions through Visibility

Visible labs have a unique opportunity to broaden public understanding of who scientists are and what they do. This can be seen through an anecdote shared by the Burke.

> There was a woman paleontologist, or she was preparing fossil specimens, and [two young girls] saw her doing that work and saw her as a role model of, like, the kind of person that they identify with being able to do that stuff. They just, like, suddenly had a different picture for what was possible for them.

Since the Burke Museum sits on the University of Washington campus, it also gets to "double stack" which invites children and adults to see people like them in higher education, providing an additional opportunity to foster a more inclusive understanding of who can occupy these spaces. NCMNS mentioned this visibility as a broader goal for this space

> We are really encouraging young people to think like a scientist and therefore you could have a career as a scientist… and I think that opens the doors of science to a whole swathe of people that are historically not able to engage.

RQ 4. Benefits and Barriers

Demystifying Science and Scientists

A major benefit of visible labs is breaking down misconceptions about scientists and science. NCMNS said this, "I feel like visible lab spaces create transparency. They are a space where visitors can say, this is what science looks like" Similarly, a researcher at DMNS said this about their experience, "I think it helps break down the concept that science happens behind closed doors... what we're doing just kind of demystifies it."

Some sites discussed having sensitive conversations with certain visitors, "I've talked to quite a few people who are like, I'm not sure about like dinosaurs being real… being able to chat with someone and have them not be judging you… definitely makes you more open-minded to

different information." Similarly, exhibit designers at NCMNS mentioned that "there's really nothing that's quite as effective as the direct interaction with the scientists."

Misconceptions

Visitors are not used to these spaces which create misconceptions, including that the lab was fake, scientists were actors, or the fossils were fake. However, in most cases, after discussions with researchers, volunteers, or staff, these ideas are debunked. It should be noted that Burke's inside-out model seems to challenge these assumptions since the entire building shows off the collections and lab spaces, this was mentioned by the interpretative staff interviewed, "I think that it does help that all we have are visible labs… it's like they either have a museum full of actors or this is, like, literally where they are doing the work." However, Burke was the only site to mention the opposite issue of visitors assuming everyone in those labs were content experts since students, visitors, or collection staff can also use the space.

Staffing Challenges

The most common challenges for visible labs were staffing issues. Sites found it was hard to keep the lab filled because of other work responsibilities, sick time, or personal matters. This also adds to the issue of completing research while entertaining guests. When discussing with one researcher, they talked about the changes they made when trying to balance work and engagement: "[I] decreased the amount that I have been opening the window and letting people come up and talk to me… I was doing it all the time and, like, losing my voice and was never getting any work done." On the other hand, sometimes it was hard to inform docents or volunteers outside the labs of sudden changes occurring. This could include a different researcher or volunteer coming in or a different specimen being looked at.

Discussions

The purpose of this research was to investigate the interpretative strategies regarding visible lab spaces in NHMs through educational frameworks. The following discussions will summarize how the emerging themes relate to existing literature and provide suggestions for future research in this area.

Processes of Science

One finding was a shift from the findings of science to the processes of science. It is unclear what is leading the shift from findings to processes of science, but it is notable since it is also occurring in exhibits, broadly, as noted by the Burke interpretation staff. NCMNS also noted a similar aim to get people to understand not only the facts but also how science arrives at certain conclusions. Exhibits shifting to demonstrate how science is performed could lead to visible labs taking a more central role in the exhibit experience. While there was no explicit mention of the NRC's (2009) strands of science learning, it appears that desired learning outcomes are represented within the purpose and motivation of these spaces. Similarly, a focus on the processes of science places the NOS as a useful framework for future educational outcomes.

One of the most valuable features of these spaces is the organic and dynamic nature of the labs. While exhibits are crafted and perfected, researchers are raw and unplanned. Visible labs carry a human and modern element that, according to the Burke evaluation, excites visitors. This unique experience is engaging for visitors because, as previously stated, it potentially allows people to humanize science and scientists but in a larger context, it brings life back to NHMs.

Demystification of Scientists and Science

The demystification of scientists and science is another major finding from this study. While it does align with previous literature, Ames (1992) and Hennes (2007). These studies demonstrated that visible labs were created to increase transparency and accessibility. Generally, that theme was geared towards collections and research. The theme from this study is more representative of displaying science and scientists organically. This differs from displaying research as a facet of the museum to demonstrating the real work done by scientists. The difference between displaying and demonstrating is that visitors confront preconceptions about this work or the people performing it. As previously mentioned, many researchers actively engaged in discussions about scientific methodology with hesitant visitors. These conversations point to a crucial element of visible labs: public engagement. It is not common for the public to easily interact with researchers. Yet, visible labs maintain this unique resource and relationship which allows the community to challenge their own preconceptions.

Public engagement with researchers has been reported previously, for example through the Portal to the Public programs (Selvakumar and Storksdieck, 2013). However, a key difference between Portal to the Public and researchers in visible labs is that programs like the former bring in external researchers and provide science. Whereas, in visible labs, researchers are already in the museum and are actively engaged in their own research while actively or passively engaging with public audiences. While, both programs fostered positive connections or impressions between researchers and museum visitors, visible labs can do this everyday without conducting programming. However, it should also be noted that that despite visible labs increasing visibility and accessibility to research visitors' comprehension of what's occurring is limited. This is also backed up by summative evaluations at COSI where they found people were engaged by the labs but struggled to understand the main message. (ILI, 2011)

Support for scientists in visible labs

More support for researchers and staff working in or around these spaces was a common theme, with flexibility and time commitments being the biggest conundrums. For example, the Burke mentioned that it was difficult to relay information when things suddenly changed. It appears that better communication tools or channels are needed between researchers inside the lab and workers outside of these spaces. One way this can be done is by utilizing whiteboards. Since whiteboards give researchers agency it's easy to update these labels with the new information. However, this doesn't perfectly solve the issue since workers outside these spaces might still feel out of the loop. Dickinson's (2020) study also found these technical issues with some institutions implementing buddy systems, radios, and, similarly whiteboards.

Researchers inside the lab should also be given more support when first getting the job. Through discussions, an issue that came up was that researchers did not fully understand that their lab would be on constant display despite the museum's best efforts to communicate this fact. Tours through their future lab space during interviews seemed to have aided NCMNS with this issue.

Personalization and Connection

A simple way for people to connect with scientists is through whiteboards. Connecting with guests through whiteboards was also found in Lopez (2016) and Wylie (2020). Traditional museum labels are polished descriptions of an exhibit, printed on durable surfaces, and conveying unchanging permanence. Unlike previous studies, this study found that whiteboards have an element of humanization. The very nature of a handwritten whiteboard underscores that

scientists are sharing what they are working on at that moment in time. Handwriting is incredibly personal and the way people write is to some degree unique to them. Every author has a unique voice, tone and style. Thus, this simple tool can amplify the authentic nature of this type of public engagement in an incredibly simple and low-cost way.

A common theme that emerged from all these sites was the ability for visitors to potentially see themselves reflected in the lab. All sites mentioned people deconstructing assumptions about scientists, and a possible future path in the sciences as an emergent feature of the labs. While this theme is notable since literature regarding this phenomenon was not found it is far from being a proven feature of these. However, this feature is exciting as it provides a pathway to interest youth in science in a more personal and engaging way.

Implications

Visible labs are a dynamic, and engaging space that provides a fascinating experience for the museumgoer. For visible lab interpretation, there needs to be a hook and contextualization of the lab, but as demonstrated by the Burke, too much information might bother visitors. The unique nature of these labs as an active display of researchers doing research in progress gives these spaces a distinctiveness that should be considered when creating interpretive material. Utilizing researchers as experts should also include an opportunity to express themselves, their research, and ideas in their own words. This is crucial for a working relationship between departments. An easy way to forge this balance and create engaging interpretative material is through personalized whiteboards.

Visible labs are excellent for creating a unique space where scientists and visitors can interact. This interaction is crucial for the space to work effectively since all the sites noted that conversations between researchers and guests were the most impactful outcome. Though this research provides the beginning of a better understanding of visible labs role in NHMs, more research needs to be conducted, especially regarding visitors' perceptions. Most of the literature regarding visible labs has focused on museum professionals, from researchers, to management, and now interpretation. While it is ambiguous about what impact conversations about science have on visitors, visible labs being safe places where interactions between the public and scientists occur in a mature and respectful way is a phenomenon deserving of more research. Similarly, information about what visitors like, dislike, understand, and perceive of visible labs would be exceptionally powerful as majority of research in this field has not explored these opinions.

Despite this research attempting to investigate a wide variety of labs, due to time constraints and available institutions, future research should look further into interpreting different scientific disciplines. In addition, a study exploring the short or long-term impacts of children viewing these spaces would add new measures of success indicating whether their assumptions about scientists and their futures are impacted.

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Appendices

Appendix A: Consent Script

I am asking you to participate in a one-on-one interview that is part of my master's Thesis work at the University of Washington in Seattle. The purpose of this research is to explore the ways in which visible labs are interpreted. I am audio recording this interview, but only I will listen to the recording. If I choose to quote you, I will not use your name but may identify your

title and institutions. Your participation in this interview is voluntary, refusal to participate will involve no penalty or loss of benefits, and you may discontinue participation at any time. If you have any questions now or in the future, you may contact me via email; I've provided you with my email address. Or you may contact my Thesis Committee Chair; I've also provided you with her contact information. Do you have any questions? Do you agree to participate in this interview?

Appendix B: Interview Guide

Thank you for taking the time to speak with me today. Before we begin, I'd like to make sure that we are on the same page with our terminology. For the purpose of this interview, a "visible lab" are areas within a museum that allow for visitors to watch current research being conducted. "Interpretation" refers, broadly, to the materials and activities the museum utilizes to aid in visitors' engagement during their visit.

Do you have any questions about the vocabulary I'm using today?

Do you want to suggest any changes to this vocabulary?

Great! Now I'd like to begin the interview by discussing some general conceptions of the visible lab space. Before moving onto the current approaches, you are using to interpret the lab, then discussing the unique opportunities and drawbacks interpreting these spaces. With that in mind:

Appendix C: Interview Questions

. What is your title and core responsibilities?

. How long have you been at this museum?

. How do you think the visible lab aligns with or enhances the museum's mission?

. What was the reasoning for the museum to create a visible lab space?

. Was interpretation of the visible labs considered from the beginning? If so, what did it initially look like?
. How have your interpretative strategies changed since then, and what factors influenced those changes?
. What role do researchers, specifically those who work in the labs, have when interpretive materials are being developed?
. Are there any partnerships or collaborations with other groups, like universities, research institutes, or community partners, that aid in interpretation of the lab's work?
. What do you hope visitors take away? Feel free to share as many outcomes as you see relevant.
. How do you assess or know what strategies are working?
. How do interpretative methods aim to communicate the process of science?
. Has there ever been a time where a result or finding from your lab changed over time? How did you handle that shift in understanding?
. How do you think visible lab spaces help improve engagement with science?
. What are some logistical challenges you face in maintaining both the research environment and the interpretative aspects of the visible lab?