# MEETING A NEED FOR "SCHOOL AT HOME": AN EVALUATION OF INFORMAL INSTITUTIONS' PANDEMIC RESOURCES FOR TEACHING SCIENCE AT HOME

A Thesis

by

KATHRYN KUNZ

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| Chair of Committee, | Joanne Olson |
| Committee Members, | Sara Raven |
| | Carl Fahrenwald |
| Head of Department, | Michael De Miranda |

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# ABSTRACT

With the advent of the COVID-19 outbreak, many public institutions were forced to close their doors around the world in order to protect the citizens, including K-12 schools. In response to these closures, informal institutions began providing at home materials for students and families to supplement the at home learning that they were doing. Because of how quickly the demand for these "at home" learning materials arose, there is very little understanding as to the quality of these lessons in regards to formal schooling. This is important because formal schools may rely on these materials to supplement or replace the at home learning students are now required to do. Science learning from home is particularly challenging due to the need for students to have access to concrete representations of scientific phenomena to support their learning of abstract concepts. Using a qualitative approach, this study evaluated the "science at home" materials developed by 12 selected informal institutions in order to answer two primary questions: 1) To what extent do the informal institutions' "science at home" instructional materials align with what is known about effective science instruction?; and 2) To what extent do the instructional materials align with school science learning goals?

# DEDICATION

I would like to dedicate this thesis to my parents. They have supported me through all of my endeavors and without them I would have never made it as far as I have. Thank you.

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## NOMENCLATURE

| | |
|---|---|
| WHO | World Health Organization |
| SS&M | *School, Science, & Mathematics* |
| SES | Social Economic Status |
| NCES | National Center for Educational Statistics |
| NGSS | Next Generation Science Standards |
| NSF | National Science Foundation |
| RTOP | Reformed Teaching Observation Protocol |
| LSC-COP | Local Systemic Change Classroom Observation Protocol |
| AIM-COP | AIM Classroom Observation Protocol |

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# CHAPTER I

# INTRODUCTION

Informal science education institutions, such as zoos/aquaria, museums, and science centers, play an important role in providing science to the public (Falk, 2001). Such informal science education settings provide a wide variety of programming and resources for children and adults, including guided field trips, school outreach programs, exhibits, camps and trips, workshops, and public lectures. Informal science education institutions frequently employ a wide range of experts, including scientists, education practitioners and researchers, exhibit designers, web designers, docents, and others. This expertise, coupled with highly localized governance structures, provides informal education institutions with adaptability to quickly create and distribute content to a wide audience.

Informal science education institutions are deemed “informal” because they are outside of “formal” schooling. As such, their mission takes into account the “free choice” intention of individuals who take part in the programming and exhibits they offer. Research on informal settings makes clear that successful exhibits must have elements of both entertainment and education to be effective. Entertainment entails both “attracting power” and “holding power”—the visitor must be attracted by the exhibit sufficiently to warrant engagement with it, and then must be sufficiently engaged to remain at the exhibit long enough for the learning goals of the exhibit to occur (Boisvert & Slez, 1995). This principle applies to single exhibits as well as the entire institution. Visitors have to want to be there, and they must remain engaged long enough to learn. Thus, informal science education institutions have a goal of teaching science, but unlike schools, they must consider issues of entertainment as an integral way to meet that goal.

Furthermore, because these settings are designed for the general public, issues of accessibility for a diverse range of ages and abilities must also be considered.

In late December, 2019, officials in China released information about a concerning novel coronavirus that was rapidly spreading in Wuhan. Because humans lacked any immunity to the virus, and due to large numbers of people traveling, the virus quickly spread around the world. The United States had isolated cases beginning in January, and by late February, community spreading was occurring throughout the country. Most states issued restrictions on travel and gatherings by mid-March, including shelter-in-place orders in states with severe outbreaks such as New York, California, Washington, Florida, and New Jersey. As of April 21, 2020, the total cases in the United States had exceeded 800,000 (Center for Disease Control, 2020). In a move not seen since the 1918-19 pandemic response, entire states throughout the country closed K-12 schools and ordered children to be remotely educated at home.

Teachers were often given just a few days to a week's notice that they needed to provide online instruction for children as young as kindergarten. Many districts sent surveys to parents to determine whether families had internet access and computers in the home. In Texas, state money was allocated to districts to purchase laptop computers for students, and several internet providers offered free internet access to low-income families.

These efforts have been fraught with challenges. Many parents are either working from home or have lost their jobs. As of April 3, 2020, roughly 6.6 million citizens filed for unemployment, a total of 4.4%, setting an all-time record. These stressed adults do not necessarily have the time or expertise to teach their children at home, particularly science. Financial instability (40% of school children in the United States qualify for free or reduced lunch) (National Center for Education Statistics, 2019), fears of illness or death from the virus, and the complete upheaval of daily life certainly exert a psychological toll on the population, including children. Elementary teachers are likely to focus their online instruction on literacy and mathematics, the two subjects that are tested with heavy consequences for children, teachers, and schools. Secondary teachers are likely to lack access to laboratory equipment and may struggle to create equivalent online demonstrations or hands-on experiences that students can safely do at home. Thus, science is quite difficult for teachers at all grade levels to move to an online format due to the need for concrete examples of phenomena, a situation likely exacerbated by the very limited time teachers had to shift their courses online. As a result, an immediate need existed for supplementary online learning resources outside of what formal schools could develop.

Recognizing these challenges, many informal science institutions rapidly produced "Science at Home" resources for families and children to use during the pandemic. These resources are intended to provide science instruction for children while they are unable to physically attend school. Due to informal institutions' high level of adaptability, these resources were provided almost immediately after schools closed. Given the labels that clearly identify these as resources to be used during the pandemic when children cannot physically attend school, parents and students are likely to assume that these resources can be used to teach school science at home, and that students will learn school science content from these resources. What is unknown at this point is the extent to which these materials are aligned with school science curriculum, and the overall quality of the resources provided in light of research on effective school science instruction. This is important to know because informal education settings have a different mission and audience than schools, and operate under very different conditions and constraints. Given the "free choice" nature of informal institutions and their historical relationship with schools as a supplement to their work, we need to understand how well their materials meet demands for “school at home.” This research is designed to address these issues.

# CHAPTER II

# LITERATURE REVIEW

While learning and education are typically associated with formal schooling, much of what we learn occurs outside of the classroom and in our everyday lives (Regmi, 2009). This idea that learning occurs beyond the just context of compulsory schooling recognizes the crucial role of family and society in shaping what we know, and also builds on the widely-held goal that individuals should become life-long learners (Goodlad, 1985). Therefore, non-compulsory schooling experiences are important in fostering this goal of life-long learning. These non-compulsory experiences are very broad, and include informal education or free-choice education experiences (Herman, et. al., 2013) as well as media, hobbies, relationships, and other lived experiences.

Free-choice learning is defined as learning that occurs in settings that are located outside of school. These interactions are typically self-paced, voluntary, and include a degree of choice in the interaction. The unique needs and interests of the learner drive engagement (Jones, et. al., 2017). These informal learning environments include, but are not limited to, zoos, museums, aquaria, nature centers, books, and field trips to out-of-school locations. Learners of all ages, sexes, educational backgrounds, and prior learning experiences visit these types of learning environments. Such environments are a social form of learning involving a process of interaction with the environment and others. Free-choice learning environments are unique in that the learner can directly interact with objects, people, or places that provide practical learning experiences from the outside world in a recreational atmosphere that encourages conversation with family and friends (Kola-Olusanya, 2005).

While free-choice informal education serves as a medium for learning and life-long learners, it also can serve an important role in filling the gap that compulsory schooling leaves behind. These settings are built to nurture curiosity as well as improve motivation and create positive attitudes about learning. Free-choice education provides a historical or philosophical context to learning that can sometimes be missed in schools (Faria, et. al., 2012), and frequently has exhibits, resources, and specialists that are impractical for schools to possess. Thus, informal education settings can provide educational experiences that both supplement school opportunities as well as support the learning of adults beyond the school years.

## Learning in a Free-Choice Setting

When entering a free-choice learning space, visitors do not expect to forcibly learn information nor do they necessarily expect to study what is being taught there. Learning is typically not the predominant reason for visitation. The primary motivations for visitors are the social interactions with friends and family, pleasure seeking, connecting with nature and animals outside of their typical interactions, and, more commonly, filling free time. Because learning is not typically the predominant factor as to why people visit their facilities, these institutions must design programs to fit the needs and interests of the different visitors that enter the space (Huang, et. al., 2019).

For preschoolers and school age children, free-choice learning institutions provide rich spaces for sensory exploration that aid in intellectual, social, and emotional development (Kola-Olusanya, 2005). These spaces can have an impact on students' achievement in school as well as how they function in society. Because students spend roughly 85% of their waking hours outside of the formal school setting, providing these out-of-school resources as another means of learning is important and due to the nature of free-choice learning settings, they encourage students to further pursue interests outside of the school setting, especially in the realm of science learning (Eshach, 2007).

Historically, schools utilize these free-choice settings for field trips to supplement to their formal school curriculum. These environments can provide students with a non-evaluative and non-threatening environment where they are free to explore their curiosities, and they encourage positive attitudes towards science for both male and female students (Eshach, 2007). That said, field trips are often structured experiences that must meet objectives that are defined by the teacher or the curriculum. As such, field trips may have some free-choice components, or none at all (Cox-Petersen, Marsh, Kisiel, & Melber, 2003; Olson, 1999). Informal settings have responded to curriculum pressures that face school group visitors in a variety of ways, including development of field trip programs that align with concepts taught in schools, adding former teachers to the staff to better respond to school needs, providing workshops and resources for teachers to use in the classroom prior to visits, and developing online resources that schools can utilize remotely, such as live cameras in zoos. Ultimately, the use of informal settings in formal schooling is shaped by the teacher and his/her curriculum, and the teacher has the responsibility to justify the use of such settings within the constraints of school-based goals and outcomes. They use these sites as a supplement for the classroom curriculum, not as replacement for it (Eshach, 2007; Cox-Petersen et al., 2003).

## Education During Pandemics

Pandemic outbreaks of disease are, unfortunately, not a new phenomenon. The most well-known pandemics include the outbreak of bubonic plague that killed 25-60% of the population of Europe between 1347, and the 1918-1919 worldwide pandemic of the H1N1 influenza virus that is estimated to have killed between 50-100 million people worldwide (WHO, 2014; Barry, 2018). However, pandemic disease has also been documented in 1510, 1665, 1688, 1693, 1832, 1847, 1848, 1889-1890, 1894, 1957, 1968, 1997, 2003, 2004, and 2009, to name a few (Barry, 2018).

Many earlier documented pandemics occurred before mandated public schooling was a common feature of society, and thus, very little is known about how schools responded during such crises. We know, for instance, that the University of Cambridge closed during the 1665 bubonic plague outbreak in London, but little is known about how primary or secondary schools responded; we can reasonably assume they responded similarly to the universities. Surprisingly little is known about schooling's response to the 1918-19 influenza pandemic. What little evidence exists is found in the medical and public health literature, and examines the influence of school closings on mortality rates and disease spread. This literature indicates that schools across the U.S. closed for extended periods of time, including K-12 and universities during the fall of 1918 when infection and death rates peaked (Barry, 2018; Bell, 2006). That said, some schools remained open, including schools in urban areas such as Chicago (Bell, 2006). A review of *School Science & Mathematics* (SS&M) and the *Cornell Rural School Leaflet* during 1918-1919 shows no explicit attention to schooling during a pandemic. One *Leaflet* article addresses the teaching of disease and hygiene to school students, but the remaining articles illustrate a "business as usual" coverage of science topics and how to teach them. SS&M added sections on the importance of supporting the World War I effort by buying bonds or enlisting in the military, showing a sensitivity to at least one major current event of the time. Despite the fact that the pandemic would kill more U.S. residents than the war did, little attention was given to education about the pandemic, or recommendations for educating students during the pandemic. Barry

(2018) indicates that school-aged children of the time stayed home and assumed duties and chores of the household, but evidence for this is scant.

School closings occurred in the U.S. in 1957-58 and in 1968 due to influenza pandemics. Similarly, evidence about schooling during these pandemics is sparse. The 1957-58 and 1968 closures occurred in isolated districts after 10-30% of the students were absent due to illness, and were temporary closures intended to alleviate the strain placed on the schools by teacher illness and other staffing shortages, and challenges in providing make-up work. In such cases, schools likely did not expect children to continue their education at home during the closure.

In April 2009, an H1N1 influenza outbreak occurred in the U.S., and the Center for Disease Control recommended that schools close for 14 days if a case was confirmed in a school (Carlo & Chung, 2009). By mid-May, 858 schools in Texas alone had closed, affecting the education of 504,696 students. Prior research has documented that during school closures for disease outbreaks, if other restrictions (such as bans on mass gatherings, business closures, or quarantine) are not in place, parents take children to public places despite public health recommendations to the contrary (Johnson, et al., 2008). During the 2009 outbreak, Carlo & Chung (2009) note that other social restrictions were not enacted at that time. These data suggest that the school closings of 2009 were temporary and were probably unaccompanied by expectations for students to continue their school studies from home.

Today's society has changed since 1918-19, creating challenges related to pandemic disease. The world's population is much larger (1.8 billion then; 7.8 billion now), and 56% live in high-density urban areas now, a number sharply rising since data began to be collected in 1951, when30% of the population lived in urban areas (Worldometer.org). The sheer complexity of society has increased, placing people in greater contact with one another than ever before

(Tainter, 1988). Schooling is compulsory until age 18 in the United States, with 56.6 million children attending a K-12 school. The rise of gyms, mega-churches, giant supermarkets, mega-malls, office cubicles, and large universities enrolling 50,000 students or more are all indicators of society's accommodation of an increasing population that does more of its daily activities in spaces designed for large groups. Large gatherings in tight quarters are what Barry (2018) described as "kindling" for a "tinderbox for epidemic disease" (p. 121).

In January 2020, U.S. officials began issuing warnings about the spread of a novel coronavirus from Wuhan, China to Europe and the Middle East. Not only did this virus share many commonalities with the 1918 pandemic (similar case fatality rates, no human immunity, high rate of infection), but the greater possibility than ever before of explosive spread due to modern travel and a higher population density made decision-making about the virus particularly urgent. Past research (e.g., Carlo & Chung, 2009) has made clear that the timing of when to close schools and the need to simultaneously restrict social contact outside of schools is crucial to reduce viral spread and save lives. Cases quickly spread to the United States in February, and decisions to close schools and issue shelter-in-place orders followed shortly thereafter in most U.S. states. In some cases, the spring semester had only been in session for 4-5 weeks, with three months or more remaining.

Unlike the 2009 H1N1 influenza pandemic, the rapid spread and high death rate showed all signs that the disease could lead to catastrophic death of the magnitude of the 1918-19 pandemic, or worse. State and local officials' responses were far more comprehensive than that of prior pandemics since the 1950s in the U.S.; when schools closed, no plans were made to reopen them for the rest of the school year. For the first time that the U.S. had experienced since K-12 schooling became compulsory, schools were closed on a large scale and teachers nationwide were expected to provide an education remotely through the use of packets of materials and worksheets, virtual Zoom meetings, and other means.

**2020 Pandemic Education**

Remote education from home where students and their families were ordered to shelter-in-place quickly faced enormous challenges. Schools immediately surveyed families to determine the level of internet and device access in the home. Prior research had shown that 94% of 3-18 year olds had access to the internet at home (National Center for Education Statistics, 2018), but as schools quickly transitioned to online instruction and expected students to join in the virtual meetings and log on to campus portals, substantial problems quickly surfaced. Schools quickly discovered that for many families in low-SES districts, a cell phone was the only source of internet access (thus inflating the NCES estimate). Parents complained on social media sites such as Facebook that the family computer was needed by parents who were also suddenly forced to work from home. The "school from home" effort had assumed that each child had unrestricted access to his/her own personal device and could follow a school schedule. One parent posted a very frustrated rant about her kindergarten child's "daily schedule" sent home by the teacher that included a full day of activities beginning at 7:30 am that looked identical to the school schedule, including reading, writing, math, science, art, and a 10 minute break for recess. The parent said the schedule was impossible to follow given her lack of knowledge of how to teach all the content and her need to work full time simultaneously. Another wrote, "I have to give up my kid or my job, I can't do both full time and do well at the same time. Sorry to vent, it's all just killing me today" (Frank, May 5, 2020). In early May, major news outlets such as the *Washington Post* began publishing articles about parental burnout from working at home while schooling their children at home (McCarthy, Gibson, Andrews-Dyer, & Joyce, 2020).

Due to the rapid closures of K-12 schools in early March, free-choice settings quickly responded by providing resources for learning science from home in the absence of formal schooling. These institutions immediately began providing lessons, activities, videos, and other forms of “at home” resources to allow students that were isolated at home to continue their learning of science. This situation was not without challenges for free-choice institutions. Historically, they have not devoted their programming to serving as the primary or sole source of science instruction for K-12 students. Education during a pandemic has created a clear need for resources that address and meet the expectations of schools, who are constrained by prescriptive standards and curricula, as well as standardized testing.

While we know that these institutions made clear attempts to meet this need for “science from home” for students, we do not know the quality of the materials being provided, nor do we understand the extent to which the materials are aligned to school goals. This study is designed to assess these issues. This study will focus on “Science at Home” resources developed during the 2020 pandemic by science-related informal institutions that include museums, science centers, and zoological facilities. The study will address the following questions: 1) To what extent do the instructional materials align with what is known about effective science instruction?; and 2) To what extent do the instructional materials align with school science learning goals?

# CHAPTER III

# METHODS AND APPROACH

## Research Questions

This study is guided by the following research questions: 1) To what extent do informal institutions' "science from home" instructional materials align with what is known about effective science instruction?; and 2) To what extent do the instructional materials align with school science learning goals?

Each of these questions was answered through a qualitative analysis of instructional materials that produced quantitative scores as well as qualitative descriptions. Both were used to draw conclusions about the quality of instructional materials and their alignment with school learning goals.

## Data Sources

For this study, materials published on the websites of informal science learning institutions that are explicitly designed in response to the COVID-19 crisis were analyzed. To qualify for inclusion, these materials must be labeled as "Science from Home" or some other identifier that indicates that the resource was specifically designed to provide science education from home during the pandemic when children were not attending school but were still expected to complete the school year.

Data sources included worksheets, activities, blog postings, demonstration videos, reading materials, and live cams of exhibits. Evaluation considered all of the available materials provided by the informal institution for at-home learning for a particular lesson.

## Selection Criteria

Four different institutions of each type of informal science setting (zoo/aquarium, museum, science center) were chosen for evaluation, for a total of 12 institutions. Two in each category are in the United States but outside of Texas, and two in each category are located in Texas. Institutions were selected by searching social media to determine what institutions were recommended by parents and teachers, including teacher blogs, Facebook pages for stay at home school, and other resources for teachers who are seeking informal educational resources for their students. Institutions were chosen if they had materials that were explicitly directed for at home science that were posted in response to the COVID-19 school shut down.

### *Assessment of Quality*

This study is seeking alignment between "at home science" instructional materials and two existing knowledge bases: 1) effective science education as defined by the consensus of the science education community; and 2) the science curriculum, which is informed by state standards (the *Next Generation Science Standards* (NGSS Lead States, 2013) in the vast majority of states). Because of this structure, a coding guide was developed in advance. Thus, this study was conducted with an *a priori* perspective of what constitutes effective science instructional materials, and what alignment to K-12 curriculum looks like.

The guide was developed by drawing upon the Local Systemic Change Classroom Observation Protocol and the AIM Classroom Observation Protocol (Horizon Research, Inc., 1999; 2014) and modified for the examination of instructional materials (See Appendix A for the coding guide). These protocols are congruent with effective science education as reflected by the science education research community and have been used widely by NSF-funded projects and reform efforts in the U.S. and elsewhere. Unlike the Reformed Teaching Observation Protocol

(RTOP) and other instruments that place a high value on inquiry-based investigations, the LSC-COP and AIM-COP are highly responsive to context and enable a lesson to be deemed effective if it is congruent with research and likely to achieve the goal of learning important science concepts. The LSC-COP and AIM-COP acknowledge that not every lesson will be dominated by student-led inquiry investigations, and that the ultimate goal of science instruction is science learning; thus the means to that end must share certain principles, but not prescriptive procedures. These principles include a consideration for student prior knowledge, accurate and developmentally appropriate content that is aligned with the intended learning goal, accurate and appropriate examples of phenomena being studied, opportunities to consider evidence, deliberate opportunities for sense-making, and a productive classroom culture. Because this study is not occurring in a classroom observation context, classroom culture is considered in light of accessibility to all students at the targeted age level, no matter their gender, SES, or geographic location. The coding guide developed for this study is consistent with the AIM and LSC protocols in their consideration of all “instruction” provided for a single science topic to be given single scores, even if instruction occurs across multiple days or “lessons.”

For each institution, materials were identified within “Science at Home” sections of the website and all materials up to two weeks (10 days) in duration were analyzed. Instructional materials for a single science topic were identified as the smallest unit of analysis. The researcher read all materials provided for that topic, and coded the entirety of those materials using the guide in Appendix A. This was repeated for subsequent topics until two weeks of material were analyzed. For example, a single institution may have 10 separate sets of scores if they posted 10 days of science from home lessons, with each day covering a different science topic.

To determine lesson quality, means were calculated for each of the items in the coding guide for each institution across all posted lessons in the first two weeks of posted materials. Descriptive statistics provide quantitative results regarding quality of the instructional materials and alignment with standards.

The coding guide contains space for the researcher to record notes that are of particular interest. This enables the researcher to note items that may be relevant to the study and may warrant revision of the coding guide, or may explain particular results. Thus, while this study is not using grounded theory to develop the initial codes (Corbin & Strauss, 2014), it was informed by the data and modified as needed. Qualitative notes were entered into a spreadsheet for easier comparison across topics and across institutions. These notes aided in the interpretation of data. Open and axial coding were conducted on the notes to develop categories from potential common themes across the materials (Corbin & Strauss, 2014). For example, perhaps a site is producing expert-led on-site video and these are far better than "try this activity in your kitchen" activities at providing accurate examples of phenomena. The notes provided space for the researcher to note particular items of interest such as this so that it could be determined if this finding was unique to one site, or is a trend across sites.

To establish consistency in coding, two researchers examined one science center and one museum's "Science From Home" postings independently and completed the institution cover sheet that identifies the stated mission of the institution and its classification, the purpose of the "Science from Home" section of the site, and the number of resources posted at the time of analysis (See Appendix A). The two researchers then coded one lesson from the selected museum independently using the coding guide, and met to discuss differences. The coding guide was slightly revised at this point to reflect the nature of the data. For example, the final section of the coding guide used the LSC-COP's scale of "Negative Effect-Positive Effect" on a number of items, and this was deemed inappropriate due to the adaptation of this guide for analysis of lessons without the ability to observe students. The scale was changed from "low-high" instead. A second lesson was coded from the selected science center and very few differences were noted during this second coding. The lead researcher of this study then coded all remaining data, and the second researcher randomly selected 5 lessons, independently coded them, and cross-checked the coding with the first researcher's data to ensure that no more than 5 of the 47 items had a difference of no more than 1 point in scoring.

## Limitations

Due to the sheer volume of instructional materials being produced and posted daily as the pandemic unfolded, assessing all materials was impossible given existing time and resources. Attempts were made to select a nationally and state representative sample of widely-publicized and utilized informal science institutions who are producing "Science from Home" or "[name of facility] at Home" resources, but determining if this sample is representative of the state and country as a whole is not possible.

A second limitation of this study is the use of a formal schooling lens to evaluate the materials. This creates a bias toward formal schooling outcomes, which is justified due to the "school at home" context, but results cannot be considered out of this context. Informal science settings have a broader mission that includes serving the public, including those who are not in school, and results cannot be applied to the other work that these settings do.

# CHAPTER IV

# RESULTS

## Introduction

For this study, 12 institutions were chosen from three different institution types--museums, science centers, and zoos/aquaria. In order to maintain an even distribution, two sites from each category were chosen from institutions within Texas, and the other two were chosen from institutions outside of Texas. The museums chosen for the study were the Adler Planetarium, the Smithsonian Museum of Natural History, the Houston Museum of Natural History, and the Mayborn Museum. The science centers in the study included the Exploratorium, the St. Louis Science Center, the Houston Children's Museum, and the Thinkery. The zoos/aquaria chosen for the study were the National Aquarium, the St. Louis Zoo, Seaworld San Antonio, and the Houston Zoo. Each intuition has their own unique characteristics that aided in enriching the study.

### *Museums*

Adler Planetarium contains many individual exhibits and attractions in addition to a traditional observatory. Located in Chicago Illinois, this institution serves a population of roughly 2,700,000 people with 41% of the population being White, 30% African American, and 29% Latino (according to the United States Census Bureau). The mission statement of this institution is as follows.

> The Adler Planetarium connects people to the universe and each other. Whether it is introducing a guest to the Ring Nebula, a neighborhood school to a community partner, a

> research team to a network of citizen scientists, or one staff member to another, the Adler's focus on meaningful connections dates back nearly a century.

They market their online resources on their opening page under a section labeled "Keep looking up". Their resources range from stories in the form of podcasts, weekly SkyWatch updates, virtual exhibits, blog posts, at home collaboration opportunities, and at home activities they market at science at home. The stated purpose of these activities is as follows.

> Feeling socially distant? Connect with us and our community wherever you are. On a cosmic scale, there's practically no distance between us. We're all flying through space on the same little blue planet, and we're all looking up at the same sky. So even though the Adler's doors are closed for now, you can stay connected with the museum, with science and astronomy, with our universe—and with other people—exactly where you are.

All lessons used for analysis came from the links provided on the "Online Resources" page. Because of the wide range of categories represented in the materials, two lessons from each resource category were chosen in order to evenly represent the resources provided. The online resource page was user-friendly and easy to navigate making finding lessons or activities just as easy. This made locating lessons and materials to evaluate a simple and straightforward process only requiring two mouse clicks to locate an at home lesson or resource. Some of the at-home resources provided were available prior to COVID-19 whereas others appear to have been posted in response to COVID-19.

The Smithsonian Museum of Natural History is a national museum located in the National Mall of Washington DC. According to the Smithsonian Institute, this free museum serves roughly 4.2 million people a year. The mission statement of this institution is as follows.

> Natural history holds the key to Earth's future. Our mission is to promote understanding of the natural world and our place in it. The museum's collections tell the history of the planet and are a record of human interaction with the environment and one another. As we all work to shape a sustainable world, this record becomes the starting point. It is our guidebook to how the future can look and work.

The lessons used for analysis were links found within a Microsoft Excel document through their learning lab link. The Smithsonian Institute as a whole has a massive collection of online learning tools. In order to identify materials for analysis, a substantial amount of digging was required, and the amount of materials available can be overwhelming. Most, if not all, the materials present appear to have been posted prior to COVID-19 and it did not appear as though any other materials/at home learning links were posted in response to COVID-19.

The Houston Museum of Natural History was founded in 1909 in Houston Texas with the goal of enhancing everyone's lives with science. Being one of the most heavily attended museums in the United States, over half a million school children visit the museum on field trips every year. In addition to offering educational opportunities for adults/families, they offer professional development workshops for teachers as well as curriculum-based field trips and science camps for students (Information retrieved from the 2019 Quick Facts and Museum Profile from the About page of the museum). The mission statement of this institution is as follows:

> When you visit the Houston Museum of Natural Science, you're not just going to one place. You're exploring tropical rainforests and worlds galaxies away. You're going back in time to when dinosaurs walked the Earth and blasting forward to the future of renewable energy. With five floors of permanent halls and a steady rotation of traveling

> special exhibits, this Houston attraction will take you beyond our walls to experience the wonder and delight of science.

The online resources were found using the "HMNS at Home" link from the main banner at the top of the home page of the museum website. Their resources range from blogs, "How To" tutorials, behind the scenes videos of their collections, science concepts/science demonstrations explained, virtual field trips, and educational activities that consist of coloring pages, word scrambles, and other activities. The stated purpose of the activities is as follows:

> We miss having you in our halls but are excited to offer digital museum experiences right in the comfort of your home. With school closures and people staying home, bringing science to you is more important than ever. Dive into our online collection with video archives and virtual tours, connect with our social media and dig even deeper with Beyond Bones.

All lessons used for analysis were located on the main page that appeared after clicking on the "HMNS at Home" banner. Each of the types of resources listed above have an individual section on the HMNS at Home page with several links below them. In order to analyze a broad range of the resources provided, if more than two were available under each resource type, two lessons were picked from each section at random using a random number generator. The page is straightforward, user friendly, and easy to navigate with links to even more at home materials free to browse. All lessons were only two mouse clicks away from many different online resources that appear to cater to a broad range of ages. There were also links within each section to further explore more at home resources that the museum had to offer. Many of the resources present appear to have been posted prior to COVID-19 with many of the videos and blogs dating back to well over a year ago (some even dating back to 2014); however, it does appear as though the frequency of materials being posted increased in response to COVID-19.

The Mayborn Museum Complex is located on the Baylor University campus in Waco Texas. The Complex consists of a natural science and cultural history museum in addition to two floors of themed discovery rooms for hands-on learning averaging between 150,000 visitors a year. This complex is owned by Baylor University and is unique in the fact that it is the location of their museum studies program, providing an academic and professional setting for learning in the next generation of museum leadership. The mission statement of the museum is as follows:

> The Mayborn Museum Complex features a natural science and cultural history museum focusing on Central Texas with walk-in dioramas including one on the Waco Mammoth Site, and exploration stations for geology, paleontology, archaeology, and natural history. In addition to the natural history exhibits, there are two floors of themed discovery rooms which encourage hands-on learning for all ages and a historic village located on the banks of the Brazos River.

Their online resources were found using the “Mayborn Museum @ Home” link that was located on the banner at the top their home screen. They had two types of resources posted, at home activities and virtual visits. The stated purpose of the lessons is as follows:

> “Mayborn Museum @ Home: fun, educational, adventures at home! Mayborn At Home is a way for you to experience the museum at home.”

The activities used for analysis were immediately found on the main page after clicking on the “Mayborn Museum @ Home” link on the main banner of the home page. Each link of the resources provided fell under the two categories of either activities and virtual visits. Six different activities from each category were chosen at random using a random numbers generator. All activities and virtual visits are in video format with experts talking about the activity/exhibit. The activities page was easy to navigate with only requiring two clicks to access the materials. Once one of the links was clicked, it brought up all the videos within the section for easy access to all materials present for that category. All activities appear to have been posted in response to COVID-19 and did not exist prior to the closure of the museum.

*Science Centers*

The Exploratorium is a science center that utilizes inquiry-based experiences to aid people in exploring the world through science, art, and human perception located in San Francisco, California. With over 800,000 visitors having walked through their doors, this institution provides a wide variety of resources both online and in person, to provide the best science education possible for its visitors. The mission statement of the institution is as follows:

> Located in San Francisco, California, the Exploratorium is a public learning laboratory exploring the world through science, art, and human perception. Our mission is to create inquiry-based experiences that transform learning worldwide. Our vision is a world where people think for themselves and can confidently ask questions, question answers, and understand the world around them. We value lifelong learning and teaching, curiosity and inquiry, our community, iteration and evidence, integrity and authenticity, sustainability, and inclusion and respect.

The online resources used for analysis could be found on the main homepage of the institutions website by scrolling down and searching below the “Learn Online with Us”. All of the activities present are arranged into five different categories. These categories include snacks with videos, tinker around your house, science snacks for K-5 kids, construct some science snacks, and learn science in your kitchen. The stated purpose of the activities are as follows:

> The Exploratorium isn't just a museum; it's an ongoing exploration of science, art, and human perception. Explore our vast collection of online experiences to feed your curiosity and education resources supporting online teaching and learning. Subscribe to our weekly newsletter and get fresh learning resources and virtual programming delivered to your inbox.

All lessons used for analysis were located under the “Science Snacks” tab on the homepage. From there, it has the five different sections that were mentioned above. Two activities from each of the sections as well as two other activities from the main page were chosen at random for analysis. The website is easy and straightforward to navigate with only two mouse clicks to get to learning materials. They can be divided by science subject, grade, family friendly, materials with videos, and science snacks in Spanish. Most of the materials present were posted before the COVID-19 closures. While the activities do not have specific posting dates, the institutions’ mission statement indicates that one of the goals of the institution is to provide online learning resources for those who cannot attend the institution in person.

The St. Louis Science Center is a free, nonprofit science museum located in Saint Louis, Missouri. Servicing over one million people each year, it is one of the largest science centers in the US.. The mission statement of the institution is as follows:

> The Saint Louis Science center combines experimentation, creativity, and play to help people discover a passion for science and technology.

The online resources were found by clicking on the banner of the home screen titled “Science @ Home” activities. From there, the viewer is directed to a main blog screen where the materials are further divided into types of materials and topics. Within the types, the information is broken up into thirteen different types of learning materials. For consistency of the study, only the “Science @ Home” materials were used for analysis. The resources found on the page included DIY science experiments, science demonstrations, connections to local scientists, astronomy facts, and live chats. The stated purpose of the activities is as follows:

> Science comes alive in your home! The Saint Louis Science Center is continuing to ignite and sustain lifelong science and technology learning by using online content to engage our guests and members of all ages to keep learning and growing. Look for DIY science experiments that can be done at home, Amazing Science Demonstrations from our Energy Stage team, connections to local scientists, astronomy updates from our McDonnell Planetarium team, live chats and more.

As previously mentioned, the activities chosen for this study were found in the “Science @ Home” section of the institution’s blog page. This was located by clicking the “Science @ Home” tab on the banner on the main home screen from the institution’s website. After clicking that tab, the screen was redirected to the main blog page where the type of online activity or the topic for the activities could be chosen. It required three mouse clicks in order to reach the at-home activities. The site is relatively easy to navigate with eleven different types of materials with fourteen different topics to choose from. Some of the provided materials such as the Night Sky Update has been active since 2016 whereas the “Science @ Home” materials began updating after the start of the COVID-19 shutdown.

The Children’s Museum of Houston is a children’s science center located in Houston, Texas. Since its doors opened, the museum has served more than one million children and families annually through not only the museum attendance but community-based programs. It currently operates thirteen bilingual exhibits, seven out-of-school/summer outreach programs, and seven bilingual Parent Engagement programs. The museum's main mission is to transform communities through innovative child-centered learning. Its mission statement is as follows:

> We transform communities through innovative, child-centered learning.
>
> The Houston region has one of the largest child populations in the United States and Children's Museum Houston serves an audience of more than 1 million children and families each year.

The resources used for analysis were found by clicking on the "educator" button on the top menu. There was no apparent advertisement on the home page for the at home learning materials. From there, the user is directed to a new page with a link to the free online curriculum materials.  From there, the user is directed to the main curriculum page. At that point, visitors can choose either by subject, grade, or exhibit. The lessons are presented in either a printable activity page or by video. The stated purpose for the activities is as follows:

> We want to keep minds going! Every day we have a lineup of LIVE activities to engage, inspire and educate your children.
>
> Enjoy learning at home with our educators? Explore our database of FREE curriculum-based activities and videos.

The at home educational materials used for analysis were the materials found under the "Science" subject filter. Because there were several pages of lessons present, the first 10 lessons that appeared on the page were chosen for analysis. The materials were mildly difficult to locate and not nearly as well advertised as some of the other online learning materials in this study, but the filter system was easy to navigate. The way the filter system was laid out made finding specific curriculum-based materials easy to find and the site specified which TEKS (the Texas science standards) topics were being addressed. Because of the fact that there are no posting dates on any of the materials, it is difficult to tell whether or not they were present prior to COVID-19. However, due to the fact that the site is catering to the TEKS, there is a good chance that the posted materials were present before COVID-19.

The Thinkery is a child-focused science center located in Austin, Texas that serves more than 460,000 children and adults annually. It is a play-based, inquiry-rich, hands-on learning environment that welcomes children and their families. This institution encourages its guests to grow not only physically and emotionally, but considers its goal to aid in cognitive development for all learners. While the target age of their visitors is newborns through eleven-year-olds, their experiences are designed to engage learners of all ages. Their mission statement is as follows:

> To create innovative learning experiences that equip and inspire the next generation of creative problem solvers.

The online resources used for analysis could be found on the home page by scrolling below the main banner and clicking on the "Thinkery at Home" link. From there, the information is broken up into blogs, activities, and videos. There is an option to download the activity guides in both English and in Spanish. The stated purpose of the activities is as follows:

> Thinkery is committed to supporting Austin's children, caregivers, and educators, as we all adjust to a new way of living and working, and serving our community where all of us are right now: At Home.
>
> While our doors may be closed to the public, for now, we're excited to keep bringing you playful STEAM learning, connection, and community engagement through fun, original, and relevant online content. We're doing this with a focus on materials and tools that are likely available in the home and require minimal preparation.

The lessons used for analysis were a combination of the activities and videos. Five activities and five videos were chosen at random. The website is easy to navigate and all of the available learning materials can easily be viewed on one page with only two mouse clicks required to access all of the materials available. The date of the posted videos indicates that the materials were developed in response to the COVID-19 crisis.

*Zoos/Aquaria*

The National Aquarium is a nonprofit organization based out of Baltimore, Maryland that has served more than 51 million guests since its doors opened in 1981. With roughly 1.5 million visitors a year, this aquarium is ranked one of our nation's top three aquariums. The mission statement of the institution is as follows:

> Our mission to inspire conservation of the world's aquatic treasures cannot be achieved without research, public confidence in scientific fact and solutions-based climate change policies.

The online resources used for analysis could be found on the main homepage of the institution's website on the top banner advertising brining the aquarium to you. The activities were all on the same screen and were divided into at home activities, puzzles, blogs, and live videos of the exhibits. The stated purpose of the activities is as follows:

> There's still plenty of Aquarium fun to experience, even from inside your home! Check out the aquatic activities below, and don't forget to tune in to our livestreams for an up-close look at our Blacktip Reef exhibit, blue blubber jellies and residents of a Pacific coral reef.

All lessons used for analysis were located under the "Bring the Aquarium to You" tab from the homepage. All of the activities were present of the main page. There were only 28 activities posted, so the ones used for analysis were chosen at random using a random numbers generator. The website was easy to navigate with the activities page being straightforward with only two mouse clicks required to reach the learning materials. It appears as though all of the materials were posted in response to COVID-19.

The St. Louis Zoo is a free institution that was established in 1910 in St. Louis, Missouri after the formation of the Zoological Society of St. Louis. The mission statement of the institution is as follows:

> Home to over 13,000 animals representing 555 species, the Saint Louis Zoo is recognized worldwide for its innovative approaches to animal care and management, wildlife conservation, research and education. One of the few free zoos in the nation, the Saint Louis Zoo attracts approximately 3 million visitors annually and is the most-visited attraction in the region.  And as a free zoo, visitors are encouraged to come back again…and again!

The online resources used for analysis could be found on the main homepage of the institution's website by clicking on "#BringTheStlZooToYou!" on the banner at the top of the home page. All of the activities present appear in blog form with videos paired with written information about the creatures at the zoo. The stated purpose of the activities are as follows:

> While the Zoo is closed to the public, we want to #BringTheStlZooToYou! We have asked our animal care team to share some photos and videos of our animals. Please keep in mind we will be operating under unusual circumstances and limited staff. Our first priority is the care and well-being of our animals, but when we can, we will be happy to add something fun and positive to your newsfeed!

All materials used for analysis were found on the main #BringTheStlZooToYou! blog page and only requiring two mouse clicks, the page is easy to navigate. Due to the fact that each page contains a single blog posting and there was no link to view a list, the first ten blog posts were used for analysis. They have also been consistently publishing blog related content to the page since August 2015, so the materials present are not in direct response to COVID-19.

SeaWorld San Antonio, located in San Antonio Texas, is part of the SeaWorld Parks & Entertainment corporation that serves its visitors not only as a theme park, but as one of the world's foremost zoological organizations that focuses on animal husbandry, behavioral management, veterinary care and animal welfare. As a rescue and rehabilitation facility, it has helped more than 36,000 animals over the last 50 years. The mission statement of the institution is as follows:

> For more than five decades, the SeaWorld Rescue team has provided a second chance at life to more than 36,000 animals, always with the goal of rehabilitating them and returning them to the wild.

The online resources used for analysis were found on the homepage of the institution's website. By scrolling down and clicking on "SeaWorld @ Home" banner on the home screen then the "learn more" button underneath the "educational resources" section, the site directs the viewer to a list with the names of animals with a "learn more" button below. Once the "learn more" button is clicked, the viewer is directed to a page with blog posts, videos, activities, puzzles, virtual rides, and information books that are all themed to the selected animal. The stated purpose of the activities are as follows:

> Dive deeper into the animal kingdom with resources and activities. Learn about these incredible animals with videos, educational activities, coloring pages and other free resources.

All materials used for analysis were located under the "educational resources" tab from the homepage. From there, twelve different animal activities were posted and for analysis purposes, ten were chosen using a random number generator. The materials were easy to find, requiring only two mouse clicks to get to the education page. The topics were in depth and provided many different types of materials for the learners. They do not have specific posting dates so it is unclear whether or not the materials were posted prior to COVID-19 or in response to COVID-19.

The Houston Zoo is a non-profit organization located in Houston, Texas. With over 2.2 million people visiting annually, the zoo has a vast reach and has several large-scale efforts to restore wildlife around Texas. The mission statement of the institution is as follows:

> The Houston Zoo connects communities with animals to inspire action to save wildlife and is committed to being a leader in the global effort to save animals in the wild. We are home to over 6,000 permanent residents (our animals) for whom we provide the highest standard in animal care. Each year, we welcome over two million guests who come to experience our incredible animals and ecosystems, and through their admission ticket or membership, help us fund the protection efforts of the counterparts of every species at the Zoo, in the wild. Through guests visiting the Zoo, we support 49 wildlife conservation projects in 27 countries around the world. We are proud to be the second most visited Zoo in the US, and the most-attended cultural attraction in the region.

The online resources used for analysis could be found on the main homepage of the institution's website by clicking on the "Bring the Zoo to You" on the banner at the top of the home screen. All of the activities are organized by day in blog form. When a day is selected, a video appears, and depending on the materials present, may also have an activity paired with the video. The stated purpose of the activities are as follows:

> Bringing the Zoo to You!
>
> Each weekday, we're hosting an 11:00 a.m. CST Facebook Live to bring the Zoo to YOU! We will be sharing daily updates of what our furred, flippered, and feathered friends are up to and how our zookeepers are caring for them while we are closed. Follow along and check out the fun at-home-learning activities below!

All lessons used for analysis were located under the "Bring the Zoo to You" link on the homepage. Because of the number of blog postings, the ten activities chosen for analysis were the first activities posted on the page. The site was straightforward, requiring only two mouse clicks to get to the online materials. The first posting date was March 16, 2020, so it appears as though the materials were posted in response to the COVID-19 crisis.

## Research Question One

To what extent do the informal institutions' "science at home" instructional materials align with what is known about effective science instruction?

*Finding #1:*

*Lessons within an institution typically have little variance in instructional quality. While lessons within an institution may have very little variance in regards to quality, wide variance exists across institutions.*

The type of institution is not related to instructional quality – all were equally likely to produce exceptional or very poor instructional materials. In order to assess overall instructional quality, a capsule rating from the coding guide was analyzed. Capsule ratings include numbered categories from 1a-5, with 1a being the lowest quality rating and 5 being the highest quality rating. The capsule rating score is an overall evaluation of the likelihood of the materials to promote learning of the intended science concept. The capsule rating is informed by scores on the other domains of the instrument (appropriateness/accuracy of science content, quality of lesson pedagogy, and likely impact on students); however, the capsule rating is an overall score and is not a mean score of the other domains. This is important as one area may be so poor that it impedes the lesson to the extent that learning is highly unlikely, thus affecting the capsule rating accordingly.

A capsule rating of 1 includes two individual categories, the 1a and the 1b category. The 1a category is indicative of "Passive Learning", where the learner is simply a passive recipient of information. It does not require any effort on the learners' end to do anything other than watch, and thus it fails to mentally or physically engage the student. The 1b category is indicative of an "Activitymania" lesson. This type of lesson involves hands-on activities and experience but it appears to be for its own sake. The lesson lacks a clear sense of purpose with no clear link to an intended science concept or evidence of conceptual development. A lesson would receive a 1a score if the pedagogy section scored low with many of the key identifiers of pedagogy being either non-existent or not consistent with what we know as effective practice. The "likely impact on students" section would also have to score low with impact either being completely absent or poor. Overall 1a/1b ratings were given to lessons that would most likely not score high in conceptual development regarding science concepts but may provide entertainment for the students.

A capsule rating of 2 is indicative of a lesson containing some elements an effective lesson. This means that while the lesson does include some elements that we know align with effective science instruction, there are still substantial problems in the design, content, implementation, and/or appropriateness for many children in the targeted age group. The lesson itself is quite limited in how likely it would enhance students' understanding of science concepts develop their capacity to successfully do science.

A capsule rating of 3 is indicative of a lesson that contains the beginning stages of an effective lesson. These types of lessons are purposeful and characterized by quite a few elements of effective instruction. Students are, at times, engaged in meaningful experiences, but there are some weaknesses in the design or content. For example, a video may tell students what they "should have found" or overlook common misconceptions that will inhibit student learning. Overall, this lesson is somewhat limited in its likelihood to enhance students' understanding of the discipline or develop their capacity to successfully do science.

A capsule rating of 4 is indicative of an effective lesson. This lesson is purposeful and engaging. The students have the opportunities to think about the phenomena, pose questions, and conduct investigations with access to high quality representations of accurate, developmentally appropriate phenomena. The lesson has a clear focus on an identifiable science concept or science process skill.

A capsule rating of 5 is indicative of a highly effective lesson. This lesson is purposeful, engaging, accessible to all students, and highly likely to enhance most students' (in the targeted age range) understanding of an important science idea or nature of science idea. It may include investigations based on their ideas with access to high quality representations of accurate, developmentally appropriate phenomena.

Because the coding guide included capsule ratings of 1a and 1b, the researcher recoded the capsule ratings using a scale of 1-6, with 1a=1, 1b=2, 2=3, and so on. The scores of all lessons coded ranged from 1-5, with no lesson receiving a 6. Of the 120 lessons analyzed, 33% were coded as passive “learning,” 30% were coded as Activitymainia, 10% contained elements of effective lessons, 9% were at the beginning stages of an effective lesson, 18% were coded as being an effective lesson, and 0% were coded as a highly effective lesson. Table 1 shows the average capsule rating for each institution.

**Table 1 Average capsule rating for each institution analyzed (Scale: 1-6).**

| **Institution** | **Average Capsule Score** |
|---|---|
| Museum 1 | 1.7 |
| Museum 2 | 5 |
| Museum 3 | 1.2 |
| Museum 4 | 1.8 |
| Science Center 5 | 2.7 |
| Science Center 6 | 3.4 |
| Science Center 7 | 2.6 |
| Science Center 8 | 2.1 |
| Zoo/Aquarium 9 | 1 |
| Zoo/Aquarium 10 | 2 |
| Zoo/Aquarium 11 | 5 |
| Zoo/Aquarium 12 | 1.6 |

*Finding #2:*

*A relationship was observed between the instructional strategies employed and the overall quality of the lesson.*

Seventeen instructional strategies were coded as either present or absent in the analyzed lessons. Out of the seventeen, five strategies were not employed in any of the lessons. These included: collected data; answered written questions on a worksheet; write reflections on a worksheet or in a notebook or journal; recognized patterns, cycles, or trends; and evaluated the validity of arguments or claims.

The number of instructional strategies employed per lesson ranged from a low of one (10 lessons used only one strategy, usually "do a hands-on activity indoors' or "read about the targeted idea/explanation of phenomenon") to a high of eight (3 lessons from Zoo/Aquarium 11). Figures 1-12 display the instructional strategies used across the lessons within each institution. They are grouped by institution type (museums, zoos/aquaria, science centers) and are arranged in descending order, with the highest capsule rating for each group placed first.

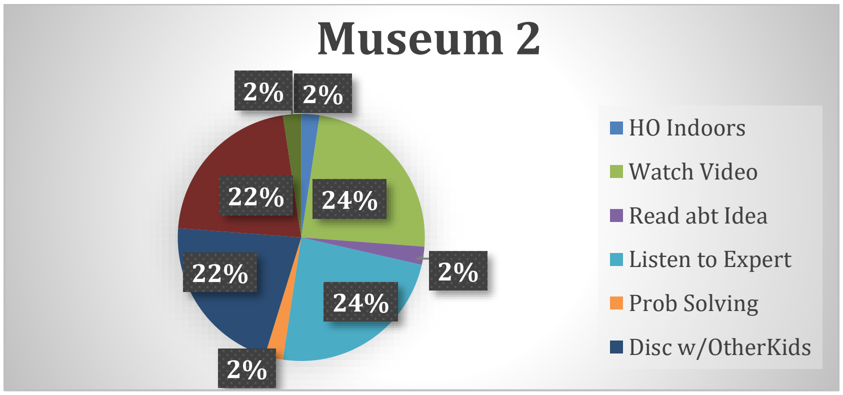


**Figure 1: Instructional Strategies used by Museum 2 with a mean capsule rating of 5.0**

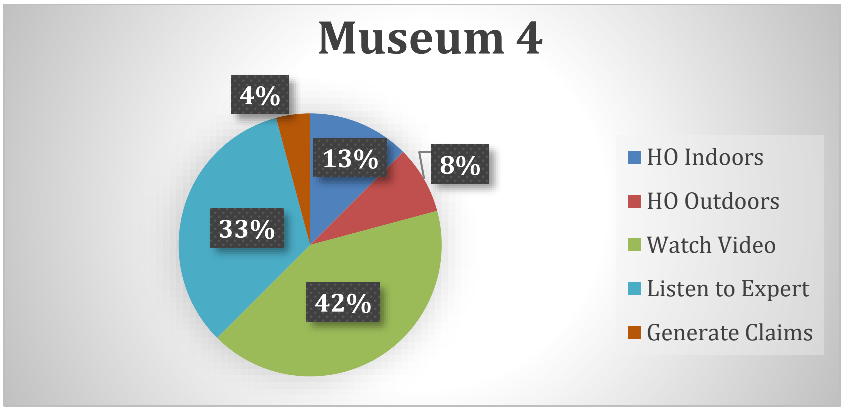


**Figure 2: Instructional Strategies used by Museum 4 with a mean capsule rating of 1.8**

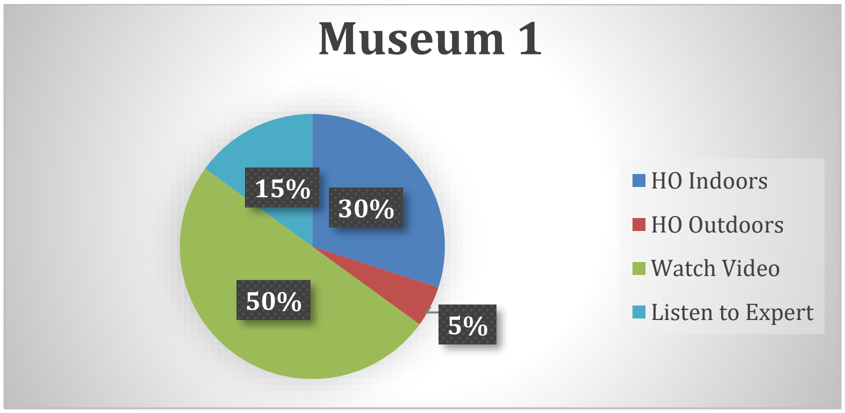


**Figure 3: Instructional Strategies used by Museum 1 with a mean capsule rating of 1.7**

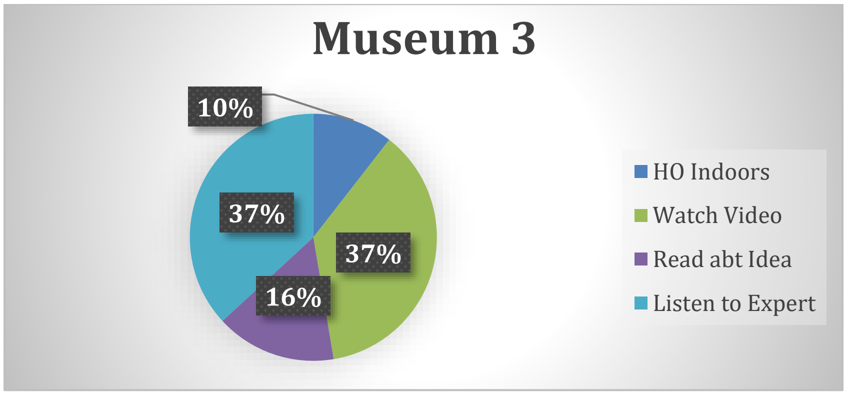


**Figure 4: Instructional Strategies used by Museum 3 with a mean capsule rating of 1.2**

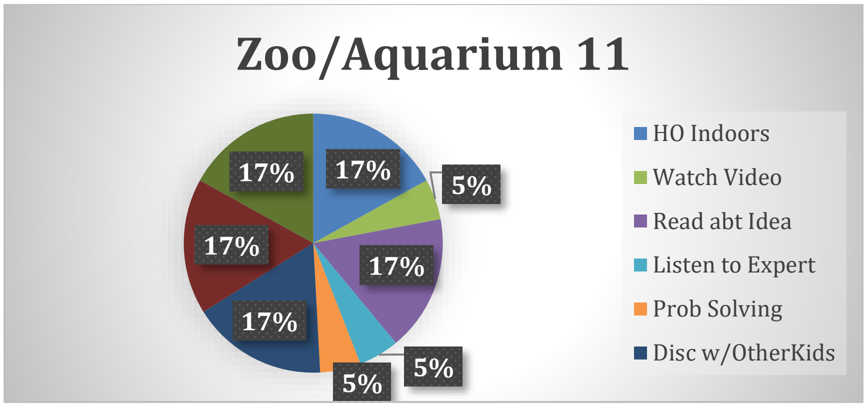


**Figure 5: Instructional Strategies used by Zoo/Aquarium 11 with a mean capsule rating of 5.0**

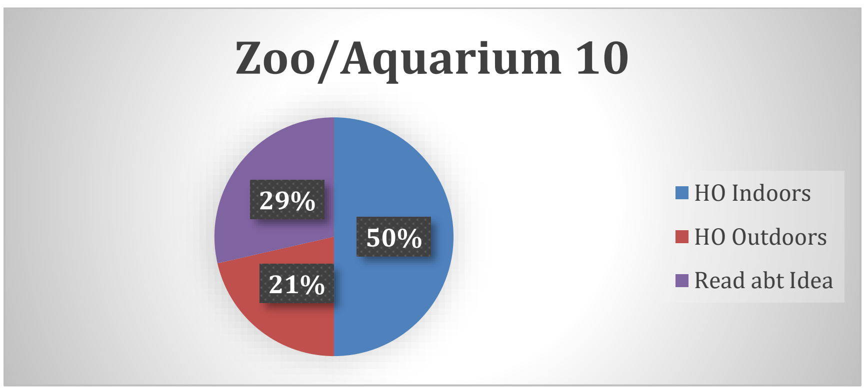


**Figure 6: Instructional Strategies used by Zoo/Aquarium 10 with a mean capsule rating of 2.0**

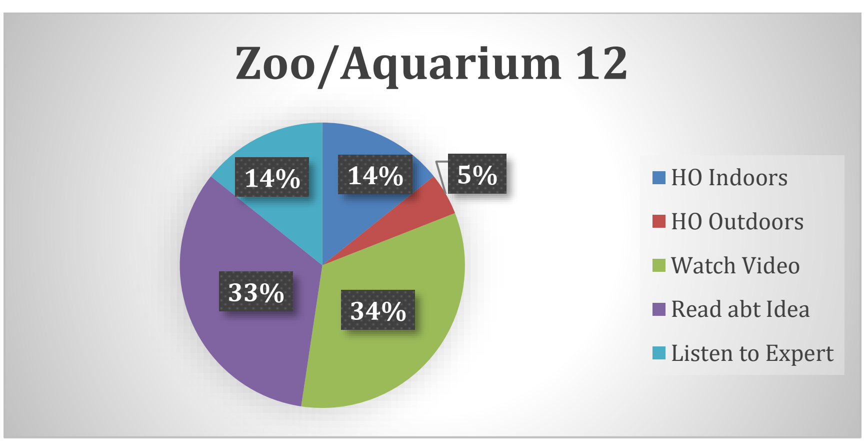


**Figure 7: Instructional Strategies used by Zoo/Aquarium 12 with a mean capsule rating of 1.6**

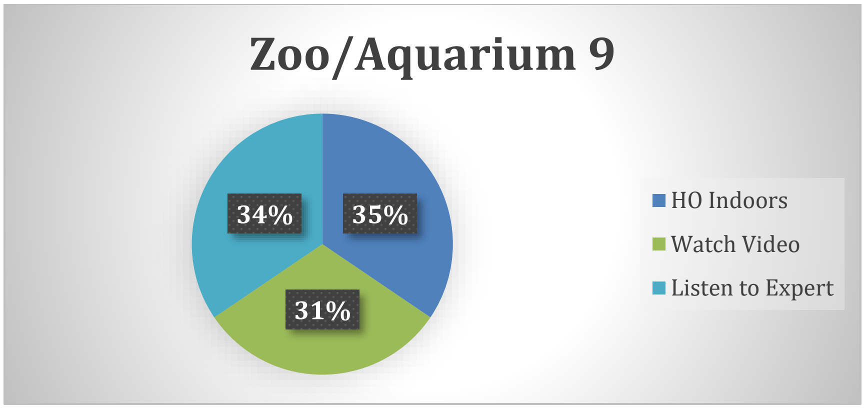


**Figure 8: Instructional Strategies used by Zoo/Aquarium 9 with a mean capsule rating of 1.0**

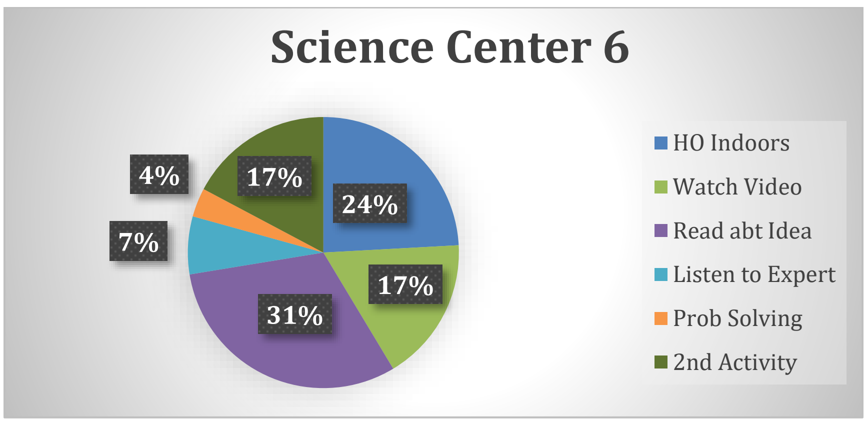


**Figure 9: Instructional Strategies used by Science Center 6 with a mean capsule rating of 3.4**

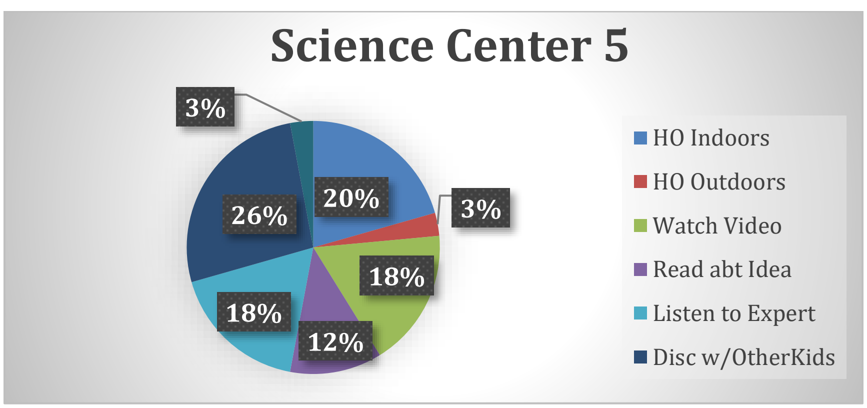


**Figure 10: Instructional Strategies used by Science Center 5 with a mean capsule rating of 2.7**

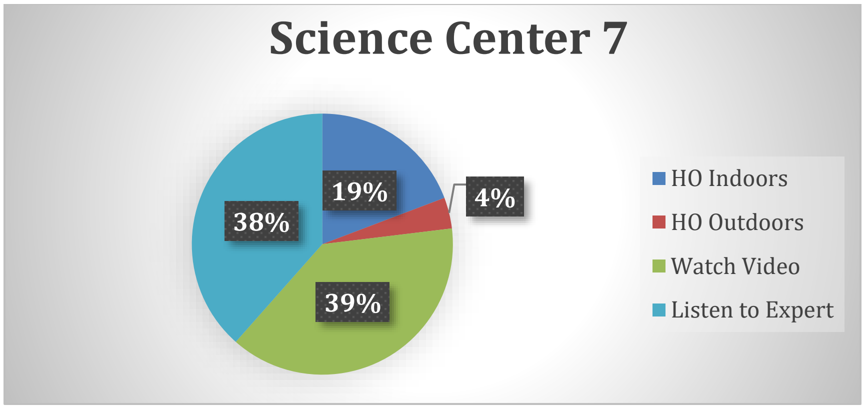


**Figure 11: Instructional Strategies used by Science Center 7 with a mean capsule rating of 2.6**

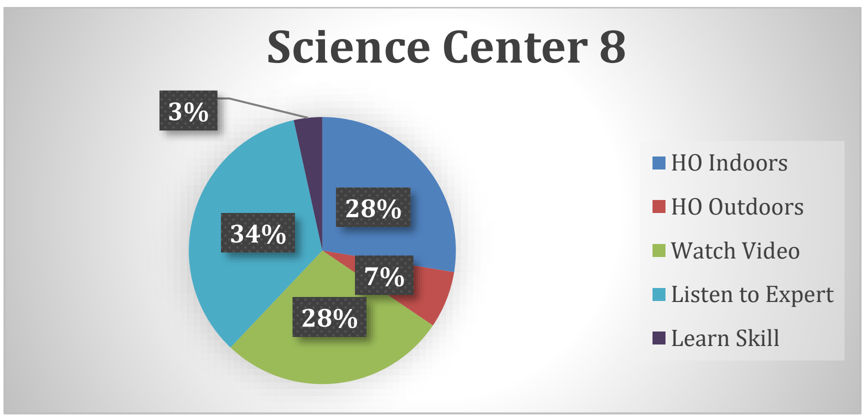


**Figure 12: Instructional Strategies used by Science Center 8 with a mean capsule rating of 2.1**

When examining the instructional strategies employed by the two highest scoring sites, they both used the greatest number of strategies (8 each). A high number of strategies was no guarantee of quality lessons, however. Science center 5, for example employed 7 instructional strategies to varying degrees, and had a mean capsule rating of 2.7. What is perhaps most important is what strategies are employed, in addition to the number of strategies present. 42% of the lessons posted on Museum 2's site and 34% of Zoo/Aquarium 11's lessons encouraged discussions between students/adults and/or students/other children; this is a marked difference from other sites. Both of these high-scoring sites also incorporated problem solving and provided a follow-up activity to deepen students' understanding and experience.

The use of a second activity that builds on the one before is a rare, but important strategy. In schools, lessons are organized sequentially. Informal institutions usually have discrete learning opportunities instead. Because school science concepts are often fairly complex, they are usually taught over multiple class periods. The use of multiple instructional activities by these two sites is consistent with models such as the learning cycle (Karplus, 1977) that advocate for an application phase where students use new information in an additional activity – this has been shown to increase learning and retention (Marek, 2008).

The top two institutions in this study encouraged discussions and incorporated problem solving. The *Next Generation Science Standards* encourages science to be conveyed not as a body of facts, but as a process of investigation about the natural world, and the knowledge that results from that investigation. To convey that message about science, instructional materials need to do more than present facts. Museum 2 promoted discussion by presenting the lesson in an animated format with a teacher addressing a group of students like they would in a typical formal schooling format. By doing so, the teacher in the video would encourage not only the animated students, but the audience of the video as well. The museum also provided a supplemental worksheet with discussion topics that aid in sense making of the topic so that whoever is leading the lesson can use it much like a script. It alluded to conversation within the video that could be used as examples to help lead the discussion. Within the supplemental materials, questions were presented in a way that anyone could lead the lesson and have high thinking level questions to ask the learner that would aid in the sense making process.

What is notably absent from many of these sites are hands-on activities to be conducted outdoors, which is surprising given the hands-on nature of these sites and the inherent need for children to spend time outdoors, particularly when studying nature. The context provided by being in an outdoor space allows for students to engage in activities that they would not be able to experience while in the classroom (Hartmeyer, Stevenson, & Bentsen, 2016). Only 11 of the 120 lessons analyzed included an outdoor experience. Five sites had no outdoor activities at all in the materials that were reviewed.

A second strategy that received surprisingly little attention, given how predominant this strategy is in schools, is reading. Seven sites included some reading experiences, but only two relied on reading in all or most of the lessons.

The most common strategy for sites to use is a video, where students watch and listen to an expert explain a phenomenon or concept. This makes sense given the medium of the internet as the source of these lessons and the potential for video to show artifacts, exhibits, and experts that students may not be able to access in other ways. That said, many sites (e.g. Museum 1, Museum 3, Science Center 7, Zoo/Aquarium 9) use these as the predominate instructional strategy, resulting in lessons that are unlikely to accomplish many important goals of science education: problem solving, designing and conducting investigations, recording and analyzing data, making claims based on data, communication, social skills, science process skills, etc. Surprisingly, only one site included the learning of a skill as part of the lesson, despite the strong emphasis in science standards nationwide on both science content and science process skills (Olson, 2018).

When reviewing instructional strategies within single institutions, each site seems to employ a similar set of instructional strategies across its lessons. They tend to use the same organizational pattern throughout their lessons. Table 2 illustrates the instructional strategies in the order they were used, for two sites selected at random: Zoo/Aquarium 10 and Museum 3.

**Table 2 Sequence of Instructional Strategies for Two Sites' Lessons**

| Site/Lesson # | 1st Strategy | 2nd Strategy | 3rd Strategy |
|---|---|---|---|
| ZA10 #1 | Reading | Hands-On Outside | |
| ZA10 #2 | Hands-On Inside | | |
| ZA10 #3 | Reading | Hands-On Inside | |
| ZA10 #4 | Reading | Hands-On Inside | |
| ZA10 #5 | Reading | Hands-On Inside | |
| ZA10 #6 | Hands-On Inside | | |
| ZA10 #7 | Hands-On Outside | | |
| ZA10 #8 | Hands-On Outside | | |
| ZA10 #9 | Hands-On Inside | | |
| ZA10 #10 | Hands-On Inside | | |
| M3 #1 | Watch Video Phenomenon | Listen to Expert Explain | |
| M3 #2 | Watch Video Phenomenon | Listen to Expert Explain | |
| M3 #3 | Watch Video Phenomenon | Listen to Expert Explain | |
| M3 #4 | Reading | | |
| M3 #5 | Reading | | |
| M3 #6 | Watch Video Phenomenon | Listen to Expert Explain | |
| M3 #7 | Reading | Hands-On Inside | |
| M3 #8 | Watch Video Phenomenon | Listen to Expert Explain | Hands-On Inside |

**Table 2 Continued**

| | | | |
|---|---|---|---|
| M3 #9 | Watch Video Phenomenon | Listen to Expert Explain | |
| M3 #10 | Watch Video Phenomenon | Listen to Expert Explain | |

Zoo/Aquarium 10 and Museum 3 have frequent repetition of instructional strategies, even though they only used 1-3 strategies in a given lesson. Despite the limited repertoire of strategies they used, they are typical of other institutions in the use of a pattern of strategies. For instance, Zoo/Aquarium 11 had the most strategies employed, and a typical sequence occurred in their use: 1) Watch video phenomenon; 2) Reading; 3) Do a hands-on activity indoors; 4) Engage in discussion with adults and/or other children; 5) Do a second activity that builds on the first.

In summary, each site tends to employ the same kind of instructional strategies with very little variation between lessons. Once they select a strategy, they tend to keep that pattern or change very few aspects of it.

*Finding #3:*

*Many institutions' resources surprisingly did not specify a targeted age group, or only targeted young children.*

Of the 12 sites analyzed, 4 had an unspecified targeted age range, 5 have a specified age range, and 3 specified an age range on some, but not all, lessons. Of the 4 that have unspecified age ranges, the materials provided appear to target a younger audience. Only one appears to be age appropriate for high schoolers (Smithsonian Museum of Natural History). Of the sites that specify targeted age ranges, as well as those that specify age ranges for some of their lessons but not others, many of these lessons provided appear to target a younger age group. This was inferred due to language used by the expert in the videos, which tended to be slower and presented in a tone that would typically be used to address a younger audience. Also, the types of puzzles and activities available tended to be simple with lot of colors as well as containing imagery that would appeal to a young audience.

*Finding #4:*

*Earth/Space science is the least represented in the materials.*

Science topics were recorded and categorized as life science, physical science, earth/space science, engineering design, arts/crafts, or "other" which includes gardening and sensory activities. Figure 13 illustrates the percentage of lessons in each topic focus.

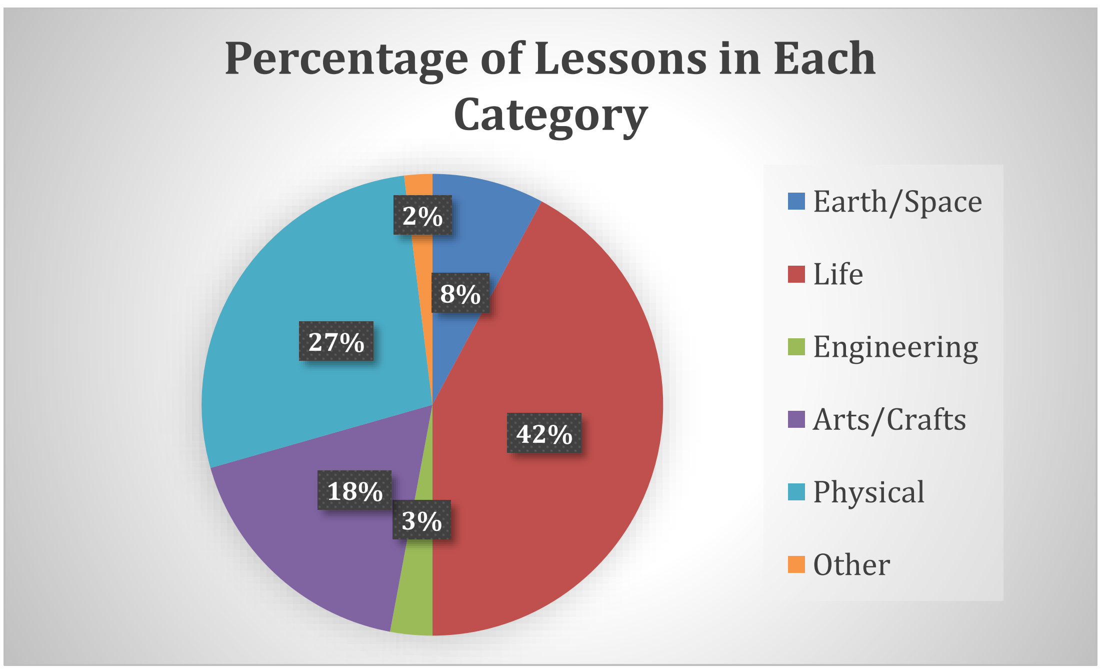


**Figure 13: Percentage of lessons for each focus topic**

Life science lessons were by far the most numerous, accounting for nearly half of the posted lessons analyzed. Physical science lessons were the second most common topic. Earth/space science was addressed only 8% of the lessons. Interestingly, 23% of the lessons analyzed were not addressing science at all despite the fact that these lessons were listed under

“Science from Home” education materials. These included art/crafting activities (18%), engineering design activities (3%), and gardening and sensory experiences (2%). The sites that had lessons with a non-science focus included 3 museums, 1 science center, and 1 zoo.

*Finding #5:*

*Despite a strong presence of science topics, a high percentage of the lessons did not have an identifiable science concept.*

To be effective in teaching science, explicit attention must be made to the science concept that is intended to be learned (Karplus, 1977). For example, a lesson on polymers may engage students in making slime, but if the chemistry of polymers is never mentioned, the activity is “science” in name only because students will not discover the vast majority of science concepts in the school curriculum merely through experience. When lessons consist of activities that are devoid of sense-making experiences that would help students learn the science content, they are called “activitymaina” (Moscovici & Nelson, 1998). 30% of lessons in this study were considered “activitymania”.

Just as science learning does not occur from activities alone, students are also unlikely to develop science ideas without concrete experiences with the phenomenon. Despite teachers’ best efforts to carefully explain science concepts, students interpret these explanations through a lens of their prior knowledge, which research has shown to be fraught with misconceptions (Posner et al., 1982). A third of the lessons analyzed in this study (33%) involved passive watching of video. Many of those videos lacked explicit mention of science concepts. The science topic is usually apparent but what exactly the end learning goal for the viewer was intended to be was unclear. For example, a video showed animals in a habitat, yet no relevant information was given to the viewer. While the main audience for these videos appears to be younger students, their ability to learn school science concepts from these activities is highly unlikely.

Some of the lessons that did have identifiable science concepts had overt statements that provided the science learning goal. Others did not have an overt statement, but the information could be extracted from the videos or written blog posts. Unfortunately, lessons that had an identifiable science concept were the exception rather than the norm, and consisted of less than one-third of the dataset.

*Finding #6:*

*Most institutions produced materials that had high content accuracy, but demonstrated many pedagogical weaknesses.*

The average score for the accuracy of science content across all lessons that had identifiable science content was 4.0 (scale 1-5). This is unsurprising due to the level of expertise of the staff at these institutions; many of these individuals have at least a bachelors degree in a science-related area (Kunz & Olson, 2019). In addition, informal institutions have valuable concrete representations as well as the facilities to demonstrate ideas and concepts that the average person does not easily come by, and contribute to the high scores on the accuracy of content.

The presence of accurate science content is certainly a positive feature, but how that content is taught to students influences how well students will learn. Unfortunately, very little, if any, attention was given to effective pedagogical practices that are known to promote science learning. Table 3 provides mean scores for pedagogy items on the coding guide.

**Table 3 Overall Mean Scores on Pedagogy Items (Scale: 1-5)**

| Item | Mean Score (composite) |
|---|---|
| Concrete representations precede abstractions | 2.85 |

**Table 3 Continued**

| | |
|---|---|
| The lesson accurately demonstrates the targeted phenomenon/science idea | 3.07 |
| Instructional strategies take into account students' prior knowledge/possible misconceptions | 1.97 |
| Lesson encourages students to generate ideas, questions, conjectures, or propositions | 2.29 |
| Lesson poses questions that promote sense-making about the phenomenon | 2.13 |
| Answers are developed by students | 1.91 |
| Questions help student consider their prior knowledge | 1.82 |
| Questions help students predict or conjecture | 1.99 |
| Questions encourage interaction with others | 1.61 |

Table 3 illustrates that very few lessons took into account students' prior knowledge and possible misconceptions, which greatly impacts how they will interpret new ideas (Posner et al., 1982). Students rarely were asked questions, encouraged to generate ideas, or were encouraged to interact with others. Only one lesson required students to record data. Only one lesson required students to generate claims. Only three institutions included lessons that had a second activity follow from the first, and only two institutions encouraged students to speak with other children or adults. In the entire dataset, only 5 lessons involved problem solving. Information delivery was the dominant perspective of pedagogy; most lessons provided accurate information to students through expert "telling" or engaged students in an activity, with the assumption they would learn that information intact and in isolation from other people and from follow-up experiences.

**Research Question Two**

To what extent do the instructional materials align with school science learning goals?

*Finding #1:*

*Few sites had lessons that aligned with concepts taught in schools.*

This is rather interesting because most institutions serve school field trip groups and are likely aware of science standards. Because these resources were found with a variety of labels that included "Science at Home" or in locations under "Education" tabs, and often explicit statements about the pandemic and learning from home, the message was often clear that they were "filling in" for the schools while schools were closed. A few provided activities claiming to teach STEM and STEM subjects, yet the activities in those cases only encouraged tinkering, arts/crafts, or engineering design.

All of the informal institutions evaluated have sections for teachers advertising for curriculum-based field trips in order to support formal learning by providing more concrete experiences to support the abstract content the school must teach. This being said, only two of the twelve sites provided at-home activities that were based on science standards that connected to topics addressed in the curriculum. Only one site had a webpage that directly referred to the curriculum and science standards that their at-home activities followed.

*Finding #2*

*Most sites targeted elementary students, which is a mismatch between the needs for "science at home" from the school's perspective and the intent of the institution.*

A full third of elementary teachers do not teach elementary science (Bayer, 2005; Banilower et al., 2018). Thus, if the intent is to provide at home what schools would normally be providing, then the need for science at home is greater in the middle and high schools. Middle and high school students are more likely to have fairly complex laboratory experiences, and such experiences would be extremely difficult for a teacher to conduct online while he/she is sheltering at home. Thus, informal institutions are ideally situated to create materials that target difficult-to-model concepts – showing demonstrations, hearing from actual scientists, and using artifacts that the sites have and teachers do not. Unfortunately, this was a missed opportunity. Middle and high school teachers were essentially left on their own by the informal institutions in this study.

Most of the activities that were provided by these institutions appear to be geared toward elementary and perhaps middle school students as well as families with young children. The majority of visitors to informal institutions are usually families with young children or elementary school field trips, so providing activities that target this age range aligns with the typical visitor age demographic of informal institutions.

# CHAPTER V

# CONCLUSIONS

Due to the onset of the COVID-19 pandemic outbreak, typical out of home activities such as formal schooling and entertainment facilities have been cancelled, outdoor spaces are closed, and any other form of outing for families is difficult considering all of the constraints placed on the public in order to provide safer spaces. In response to the need for online resources that families can acquire in their own homes, informal institutions have provided online resources to "Bring the [Name of Institution] to You" and aid in the at-home learning and entertainment that students and parents are now having to navigate.

Overall, the informal institutions studied here were highly responsive to school closings and worked quickly to provide resources that children could use in an effort to learn science from home. Lessons and videos were posted almost immediately following widespread closure of schools in March, 2020. The content that was provided by these institutions was accurate and utilized the experts and exhibits from these sites in ways that teachers would be unable to provide. This illustrates the strength of informal institutions and their potential to serve as a responsive resource and school partner. The presence of experts and high-quality video production and website design, coupled with exhibits that cannot be replicated in a school can be leveraged to create high-quality educational opportunities under these circumstances. This was seen in the case of Museum 2 and Zoo/Aquarium 11, who provided a variety of carefully sequenced experiences to help build conceptual understanding of science concepts.

What was lacking in the majority of the materials was explicit sense-making about science concepts. Most frequently, concepts were either told to students or overlooked completely – neither of which is likely to promote science learning (Banilower et al., 2018). Pedagogical strategies that involve pondering and generating questions, collection and analysis of data, proposing explanations, interacting with someone else, and using new ideas in a follow-up experience are all known to be important in helping students learn science (Karplus, 1977; Banilower et al. 2018). However, these strategies were rarely employed, and 63% of the lessons involved students passively watching a video or engaging in "activitymaina" – activities where connections to concepts were not made. In fact, a substantial percentage of lessons identified as "science at home" were not about science at all, or contained no evidence of a clear science concept.

The vast majority of the learning materials presented relied on video demonstrations of the phenomenon in question or how to perform/set up activities. Very few heavily relied on the use of reading materials. If provided, reading materials usually served as a supplement to video demonstrations. In one sense, the lack of reading is probably not concerning, given how reading-intensive schools have become since the No Child Left Behind Act mandated testing and reporting of scores in language arts and mathematics (Center on Education Policy, 2008). Reports have indicated for years that teachers over-rely on textbooks that teach science and that this is detrimental to students' learning, particularly as they are used in classrooms (Banilower et al., 2018). Despite these concerns, a pedagogical "bright spot" exists. The fact that the institutions studied here did not rely on the reading of text, and relied heavily on hands-on activities and watching phenomena, indicates that institutions are aware at some level that students need concrete experiences with phenomena.

The central challenge faced by teachers, parents, and informal institutions was to provide learning opportunities for students so they could finish out the year and complete the required curriculum. Few of the informal institutions studied here aligned their experiences with the school curriculum. Elementary lessons predominated, and seemed to be selected based on convenience (e.g., the presence of reptiles at the site) or the “fun factor” (e.g., making slime). Most of these experiences were discrete – that is, they were stand-alone single lessons that could be completed in any order. While many were certainly interesting and could entertain students, few could be considered a continuation of the school science curriculum. In the case of the high school science curriculum, not one institution studied provided materials that explicitly addressed the needs of high school students in learning school science from home.

While most, if not all, of these institutions advertise for curriculum-based activities and field trips for schools, only two of the institutions actually provided materials that have curriculum-based learning outcomes. Because all of these institutions already serve school groups and had some curriculum materials prior to the pandemic, it is odd that only two institutions offered online learning that are curriculum-based. The result was a missed opportunity to provide online resources for education at home. With the exception of the two institutions that were evaluated as having curriculum-based learning materials, the other institutions included materials of which 30% are primarily activity based with little to no clear learning outcomes and 33% are passive learning experiences. Over 60% of all the learning materials were unlikely to result in science learning.

Looking at the types of materials present, they are usually geared toward younger students, despite the need for science at home to include middle and high school students. Many advertise that they are suitable for all ages, but the content, if present at all, is not aligned to concepts found in the upper grades. Informal settings’ historical interactions with schools have been field trips, which are usually at the elementary grades due to scheduling issues with secondary class schedules. They seem to have maintained this bias toward elementary students and overlooked the severe needs of secondary teachers.

The response of informal institutions is certainly consistent with the multifaceted mission of their work and their typical visitor demographic. These institutions were not designed to replace schools, nor were they intended to mimic the school curriculum. The nature of free-choice education focuses on visitors’ ability to decide for themselves what they want to learn and do. While there is a learning goal for every informal lesson, it is the choice of the learner to participate in the lesson. The primary visitor demographic of informal institutions has historically been elementary school children and families with young children. Thus, the lack of alignment with school science curricula and the lack of lessons appropriate for high school science content is unfortunate, but unsurprising.

Despite the ongoing nature of the pandemic in the United States into the fall of 2020 semester, with many schools continuing to operate remotely, institutions that have re-opened are no longer actively advertising their “at home” learning materials. Viewers either have to search for the materials or the materials have been removed. For example, the National Aquarium has completely removed their “at home” learning materials, and they can no longer be found, even by using the search feature. An important issue to raise is why this has occurred, when the need still exists. One possibility is that by providing “science at home” a visitor may not be compelled to get their “science on site” by purchasing admission and visiting in person. Informal institutions are costly, and most are dependent upon ticket and event sales. While we cannot be certain why the materials are being removed, this raises an important issue about the relationship between informal institutions and schools and what that relationship should be.

With the onset of the pandemic, parents had to deal with a level of stress that many had never experienced before. Not only do many have to work fulltime in order to support their families, they also have to triple their duties as fulltime educators and childcare providers. Traditionally, schools served two of these roles, as educators and childcare providers, for 7-8 hours a day. They were responsible for teaching children the required subject matter knowledge, but also providing socialization, nutrition, supervision, exercise, and other important life skills. Parents do not have the time nor the energy to work two fulltime jobs, particularly when many parents are in financially precarious situations and the economy struggles. Cooney (2020) summarizes these points very well: "We are expected to work from home full time. And care for our children full time. And we cannot have anyone outside our immediate household help. It can't work and we all are suffering at the illusion that it does." Because of this struggle parents are now facing, having resources to ease this burden are vital.

Rather than expecting informal institutions to pick up the slack with little or no guidance, this pandemic has opened a door for a prime opportunity begin to bridge the gap between formal and informal institutions. By pairing the experts with their exhibits, and teachers with their knowledge of required curricular content and learning pedagogy, these individual entities could create content that would not only benefit students during the pandemic, but once the pandemic is over as well. Both entities have historically worked together to provide learning experiences for students during field trips. Moving past the pandemic, this partnership is one that could benefit students on a much larger scale. By providing experiences that students could have when travel is prohibitive, informal institutions could be a valuable partner for schools to support students' learning of curricular content. Students may not have the means to visit institutions outside of their city, and it is a grave disservice for all not being able to utilize the amazing content that these informal spaces around our country have to offer.

Considering the current constraints as well as the short and demanding timeline many of these institutions had to face, the materials created did provide something that could be used by students at home and certainly provided an "inside look" at these institutions, their experts, and their exhibits. In these challenging times, our world has had to adjust and adapt to something that no one in this lifetime has ever had to experience. To expect informal institutions to serve a population they have typically not served, and respond to formal curriculum demands when their niche has been informal education is certainly a challenge, and an expectation that could be considered unrealistic. The fact that these institutions rose to the occasion and prepared materials to support learning at home in such a short period of time is commendable. Not only did informal institutions step into this challenge very quickly, but formal schools, students, and parents all went above and beyond what anyone could have expected. Asking more from these individual entities who have already done so much is likely unrealistic without partnerships in place to provide necessary expertise in order to successfully fill the need for K-12 science from home materials that are aligned to the curriculum and consistent with effective practices in science education.

Although these informal institutions missed an opportunity to provide at home resources that were tightly aligned to school curriculum, the bigger question is whether they were the appropriate institutions to have filled that gap in the first place. The nature of informal institutions is inherently about free-choice learning, and these institutions have a valuable role in providing experiences that go well beyond the limited topics taught in school. Visitors have the choice as to whether or not they want to learn or simply entertain themselves with things that they typically cannot find on a daily basis. By attempting to cater to the need for formal educational materials, these institutions must inherently abandon the notion of free-choice learning for these materials. Many of the activities evaluated appeared to have a sole purpose of entertainment. As previously mentioned, parents and their children are trying to find ways to navigate this new norm and having activities that families can do together without the primary focus of the activity being formal learning, may be useful to meet family goals, such as entertainment or informal learning. Giving parents and their children something to do in the comfort of their own homes that is accurate and uses the representations that only informal institutions can provide can be very helpful in this stressful time. So, to answer the previous question, these informal institutions should not be expected to work independently to fill in a gap left by the closure of formal learning institutions. While they can serve as a vital resource in supplementing learning from home, they should not be relied upon to serve as the only solution. Other institutions exist that may be in a better position to either develop and distribute at-home materials and/or work with informal institutions to develop such materials. These include local area education agencies, county offices of education, science consultants and curriculum coordinators in state departments of education. They are highly familiar with the curriculum and expectations for science in K-12 settings, they are also aware of the needs of teachers, and they have science content expertise.

The willingness of informal institutions to try to fill a need when students were learning science at home was laudable. Results of this study indicate that the materials were entertaining and likely to increase students' interest, but were less likely to promote learning of school science concepts, particularly for middle and high school students, and particularly in the earth/space sciences. This study raises important issues about what can be expected of informal institutions in this role, given their free-choice nature. Closer partnerships between formal and informal settings are likely necessary in order for informal institutions to better respond to the needs of schools during crisis, if such expectations are to be placed upon them.

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APPENDIX A

# Institution Cover Sheet

**Name of Institution:**

**Classification of Institution:**

**Zoo/Aquarium** **Science Center** **Museum** **Other**

**Date of Analysis:**

**Number of "Science at Home" activities posted at time of analysis:**

**Number of Lessons:**

**Stated Purpose of Activities (if any):**

**Stated Purpose/Mission of Institution:**

**Types of resources provided on the site:**

**Notes:**

## I. Background Information

A. Name of Institution:

B. Name of Lesson Analyzed:

C. Date of Posting:

D. Targeted Age Group: preK K-3 4-6 MS HS unspecified other

E. Mention of Science Standards or an Existing Curriculum? Yes No

F. Identifiable Science Concept? Yes No

If yes, state the concept here:

G. Is adult science content knowledge required? Yes No

H. Lesson Focus: Science Engineering Design Arts/Crafts Other: ________
Life Earth/Space Physical

Notes:

## II. Structure & Accessibility

A. Organized by: (check all that apply)

__ Age group

__ Topic

__ Other (specify): ______________________________

__ None/No Organizational Principle Evident

B. Lessons are: (check all that apply)

__ Discrete (free-standing, disconnected from other lessons)

__ Topically Linked (grouped by topic, but could be done in any order)

__ Conceptually Connected (concepts build or connect across multiple lessons)

C. Concrete materials required to do this lesson are:

__ Accessible for all participants (If not, note why)

__Safe/developmentally appropriate for targeted age group

__ Require adult supervision

__ Not specified or required

Notes:

## III. Quality of Lesson

| | N/A | Not Consistent w/Effective Practice | Somewhat Consistent w/Effective Practice | Moderately Consistent w/Effective Practice | Highly Consistent w/Effective Practice |
|---|---|---|---|---|---|
| **A. Content** | | | | | |
| The science content is accurate. | 1 | 2 | 3 | 4 | 5 |
| The science content is developmentally appropriate for targeted age group. | 1 | 2 | 3 | 4 | 5 |
| **B. Pedagogy (strategies and teacher behaviors)** | | | | | |
| Concrete representations precede abstractions. | 1 | 2 | 3 | 4 | 5 |
| The lesson accurately demonstrates the targeted phenomenon/science idea. | 1 | 2 | 3 | 4 | 5 |
| The instructional strategies take into account students' prior knowledge or possible misconceptions. | 1 | 2 | 3 | 4 | 5 |
| The lesson encourages students to generate ideas, questions, conjectures, and/or propositions. | 1 | 2 | 3 | 4 | 5 |
| The lesson poses questions that promote sense-making about the phenomenon. | 1 | 2 | 3 | 4 | 5 |
| Answers are developed by students. | 1 | 2 | 3 | 4 | 5 |
| Questions help students consider their prior knowledge. | 1 | 2 | 3 | 4 | 5 |
| Questions help students predict or conjecture. | 1 | 2 | 3 | 4 | 5 |
| Questions encourage interaction with others. | 1 | 2 | 3 | 4 | 5 |

What instructional strategies are employed and in what order?

- __Watch video phenomenon
- __Do hands-on activity indoors
- __Do hands-on activity outdoors
- __Engaged in problem solving/investigation (kids have some latitude in designing investigation)
- __Collected data (observational, measurements, etc.)
- __Answered written questions on a worksheet
- __Wrote reflections on a worksheet or in a notebook or journal
- __Read about the targeted idea/explanation of phenomenon
- __Listen to expert on video explain the phenomenon
- __Engage in guided discussion with adult/parent about the phenomenon
- __Engaged in discussion with other children
- __Recorded, represented, and/or analyzed data
- __Recognized patterns, cycles or trends
- __Evaluated the validity of arguments or claims
- __Generated claims based on evidence
- __Do a second activity that builds on the first
- __Learned or practiced a skill

| **C. Likely Impact on Students** | **Absent** | **Poor** | **Satisfactory** | **Good w/ some limititations** | **Excellent** |
|---|---|---|---|---|---|
| Students' understanding of science as a dynamic body of knowledge generated and enriched by investigation | 1 | 2 | 3 | 4 | 5 |
| Students' understanding of important science concepts | 1 | 2 | 3 | 4 | 5 |
| Students' capacity to carry out their own inquiries | 1 | 2 | 3 | 4 | 5 |
| Students' ability to apply or generalize skills and concepts to other areas of science, other disciplines, or real-life situations | 1 | 2 | 3 | 4 | 5 |
| Students self-confidence in doing science | 1 | 2 | 3 | 4 | 5 |

| | Poor | Slightly | Neutral | Good | Highly |
|---|---|---|---|---|---|
| The lesson will entertain/motivate students | 1 | 2 | 3 | 4 | 5 |

| | Not at all related to school curriculum | | Somewhat connected to school curriculum | | Highly connected to school curriculum |
|---|---|---|---|---|---|
| What is the likelihood that this lesson will result in continuation of the school's science curriculum? | 1 | 2 | 3 | 4 | 5 |

## D. Capsule Rating of the Lesson

**1a** **Passive "Learning"**—Students are passive recipients of information

**1b** **Activitymania**—Students are involved in hands-on experiences, but it appears to be for its own sake. The lesson lacks a clear sense of purpose and/or a clear link to conceptual development

**2** **Elements of an Effective Lesson**—The lesson contains some elements of effective practice, but there are substantial problems in the design, content, implementation, and/or appropriateness for many children in the targeted age group. Overall, the lesson is *quite limited* in its likelihood to enhance students' understanding of the discipline or develop their capacity to successfully do science.

**3** **Beginning Stages of an Effective Lesson**—The lesson is purposeful and characterized by quite a few elements of effective instruction. Students are, at times, engaged in meaningful work, but there are some weaknesses in the design or content. For example, a video may tell students what they "should have found"; the lesson may overlook common misconceptions that will inhibit student learning, etc. Overall the lesson is *somewhat limited* in its likelihood to enhance students' understanding of the discipline or develop their capacity to successfully do science.

**4** **Effective Lesson**—The lesson is purposeful and engaging. Students have opportunities to think about phenomena, pose questions, and conduct investigations with access to high quality representations of accurate, developmentally appropriate phenomena. The lesson has a clear focus on an identifiable science concept or science process skill.

**5** **Highly Effective Lesson**—The lesson is purposeful, engaging, accessible to all students, and highly likely to enhance most students' (in the targeted age range) understanding of an important science idea, NOS idea, or science process skill. Students have opportunities to think about phenomena, pose questions, and develop investigations based on their ideas with access to high quality representations of accurate, developmentally appropriate phenomena.

Notes: