Winter 12-15-2018

Making Space for Makerspace: How Adding a Makerspace can Benefit Art Museum Education Programming

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Keywords: constructivism, inquiry based learning, intellectual scaffolding, makerspace, multiple intelligences, multisensory, museum studies, open ended learning, progressive education

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Capstone project submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Museum Studies

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December 14, 2018

Acknowledgements

Thank you

To my family and friends for your support
To Aiyana, Katie, and Ana Pao for making sure I cross the finish line in stride
To my professors, and the USF Museum Studies Program for believing in me
To SFMOMA, for my internship and for opportunities to plant my museum roots
To my museum mentors, like Deena, for being examples of what I hope to be
To my capstone advisor, Marjorie, for everything

And to John, who took a chance on me that led me to my wildest dreams. Your patience, kindness, and guidance mean more to me than I can say.

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Abstract

In this capstone project, I advocate for adding makerspaces to art museum education programming. I review the foundational educational concepts of a makerspace which help explain why it is a modern strategy to increasing visitor learning. This includes John Dewey's theories of experience and education, Howard Gardner's multiple intelligences theory, George Hein's studies of museum visitor behavior, and the physiological science of learning. I then propose four key terms essential for visitor learning, and explain how makerspaces successfully incorporate them. The four key terms are: 1. multiple intelligences, 2. direct experience, 3. inquiry based and open ended learning, and 4. dynamic physical space. I conclude with my recommendations for an art museum interested in creating and maintaining a makerspace, using several examples from museums of all types that currently offer makerspaces as part of their programming.

Chapter 1: Executive Summary

In 2005, *Make: Magazine* was founded. In 2006, *Make: Magazine* hosted the first Maker Faire in San Mateo, California. Now, in 2018, makerspaces, fab labs, think tanks, and DIY studios are scattered worldwide, in schools and universities, libraries, homes, community centers, and museums. What is a makerspace? And what is it about makerspaces that allow them to engage children, teens, adults, families, scientists, musicians, technicians, and everything in between? The answer lies in its educational roots, which are much more aligned with our present day understanding of how people have fun, think, learn.

A makerspace is a learning environment that draws from concepts from the Progressive Education Movement. The **Progressive Education Movement** was a period during the 20th century where educators thought critically about the Industrial Revolution based public education system, as well as the efficiency of old and current methods for presenting information to achieve greater comprehension and understanding. In the literature review of this capstone proposal, I review theories by three major key Progressive educators: John Dewey, Howard Gardner, and George Hein, and how their theories are intertwined with our current understanding of the human central nervous system, sensory organs, and the physiological process of learning. I then illustrate how these theories create the foundation for makerspaces, and explain why makerspaces are efficient educational tools that attract diverse audiences.

In my proposal, I advocate for the addition of makerspaces to art museum education programming. I review my definition of a makerspace, and four key terms for successful visitor learning, derived from my research and experience in museum education. Using examples from fifteen museums of all disciplines, I explain the importance of each term, best practices for implementing them, and why the makerspace specifically is the ideal educational tool to emulate them. I then outline my recommendations for an ideal makerspace, including the intentions of a makerspace; the leadership involved; creating defined educational outcomes; intellectual scaffolding; staffing and training; physical design of the space; budgeting; funding; and evaluation techniques. The goal of this proposal is to serve art museums interested in creating and sustaining a makerspace within their institution.

I conclude with suggestions for further research, important concepts that influenced my research but were outside the scope of this project, and why it is so critical for makerspaces and our current understanding of learning need to continue to find space in museums.

Chapter 2: Literature Review

A makerspace is not a room. It is not a fad-of-the-moment. It is a deeply-rooted concept.[1] The Maker Movement has resulted in an infinite amount of uncommon learning pathways for today's students. The logic behind why makerspaces are such valuable spaces for learning draws from the theories of European researchers whose work I will not delve into in this capstone because of space constraints[2]. Their research in turn influenced progressive American educators like John Dewey, Howard Gardner, and George Hein. Dewey stressed the importance of learning through experience, while Gardner advocated that educators understand the many ways in which people learn. Hein synthesized the museum experience into tangible patterns and observations that when implemented make a significant difference in a museum's ability to successfully translate their educational goals to visitors. While the long standing repertoire of art museum education programming is undoubtedly vital to reaching and interpreting content for a percentage of visitors, museums struggle to reach and retain wider and more diverse audiences due to their traditional pedagogies and lack of attention to the work of these theorists and other kinds of museums that have successfully responded to and implemented their research. A makerspace is the ideal tool to implement the findings of the progressive education movement and modern science in order for a museum to achieve its desired educational goals. As art museums of the 21st century make a commitment to be visitor-focused and audience-centered, it is imperative that the present day understanding of how humans learn and how people navigate and interact

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[1]Colleen Graves, Aaron Graves and Diana L. Rendina, *Challenge-based Learning in the School Library Makerspace* (Libraries Unlimited, 2017), 1.

[2] Jean Piaget, Howard E. Gruber and J. Jacques. Vonèche. *The Essential Piaget.* J. Aronson, 1995.
Maria Montessori and R.C Orem. *A Montessori Handbook: "Dr. Montessori's Own Handbook."* Capricorn Books, 1966.

with museums are embraced and implemented in substantial ways. This capstone argues that adding the makerspace concept to the art museum education portfolio, all visitors can have a powerful opportunity to learn in deeper ways, allowing them to give the art in question personal meaning rather than simply being told they should appreciate it.

Early places of education have long favored particular learning styles, especially ones that relied on visuals. Due to the scientific advancements of the Enlightenment movement, people understood the eyes as the primary point of human observation and understanding, believing sight was the only significant way to gain and retain knowledge. During the modern age, some educators and philosophers began to view the human mind in a much more vivid, complicated light. Among them was John Dewey, turn-of-the-20th century philosopher who advocated for an alternative interpretation of how humans think, learn, and grow. Working against the highly regimented factory schooling that resulted from the Industrial Revolution, he viewed the process of education as a continuous growth across a lifetime.[3] Against popular opinion, Dewey was adamant about the deep and continuous connection between humans and the environment, and that in turn all learning resulted from our experiences in and of the environment around us. The essence of “experience” is that it is personally engaging. As museum marketing expert Neil Kotler has explained, experiencing connotes active engagement (direct observation of or participation in an event), immediacy (knowing something through sensory stimuli), individuality (something that is lived through), and intense, memorable, or unusual encounters.[4] Dewey reasoned that because we are born and live in an ever-changing environment, that we are always learning and growing, and that survival is the very result of

[3] Sylvia Martinez and Gary Stager, *Invent to Learn: Making, Tinkering, and Engineering in the Classroom* (Constructing Modern Knowledge Press, 2016), 14.
[4] Neil Kotler, "Delivering Experience: Marketing the Museum's Full Range of Assets," Museum News, 1999, 32.

adapting, which is the result of learning from our experiences. For Dewey, learning and knowledge are not fixed, finite points to be mastered. Rather, knowledge is gained when we interact with our environment, and as we collect new data points of different experiences, our knowledge will grow and shift to combine, replace, and hybridize what we've learned with what we know. Dewey recognized that mere activity does not constitute experience. Change is meaningless transition unless it is consciously connected with the return wave of consequences, which flow from it. When an activity is continued into the undergoing of consequences, when the change made by action is reflected back into a change we make in us. The mere flux is loaded with significance. We learn something.[5] Dewey explained that thinking is the accurate and deliberate instituting of connections between what is done and its consequences. It notes not only that they are connected, but the details of the connection, in the form of relationships.[6] Knowledge is the accumulation of observations and experiences, while thinking is the active connection between knowledge gained, and learning is our understanding of the consequences and conclusions of those connections. Dewey's understanding of this cycle requires an active participant, which is why he rejected the stagnant, one-way explanation of information which dominated public schools and the overall education system in America epitomized by straight rows of desks, from which children recited facts they had memorized but probably not synthesized. For Dewey, one cannot learn by sitting still and silently while being lectured to about an esoteric subject by another individual. He also disagreed with the notion that education has an attainable end. Because our environment is actively living, so too are its inhabitants. The process of living is continuous; it possesses continuity because it is an everlastingly renewed process acting upon the environment and being acted upon by it, together with institution of

[5] John Dewey, *Democracy and Education: An Introduction to the Philosophy of Education* (Free Press, 1966), 139.
[6] Ibid., 151.

relations between what is done and what is undergone.[7] For these reasons, Dewey could not condone the current education system of passivity. Dewey saw learning as a process of problem solving. For genuine learning to take place, it must be real to the student, the process must actively engage the learner. The fault with the traditional school is the passivity of the learner, who is expected to absorb, without question, the prescribed curriculum through drill and rote exercise.[8] Many students cannot learn sitting still and silent in an isolated classroom while a teacher lectured on the phenomena of the external environment. In order to learn, the students needed to experience concepts for themselves, to be actively engaged, obtaining an individual, immediate, and intense encounter. While Dewey did not agree with the current education system due to its lack of direct experience and understanding of organic thinking and learning, he highly coveted education as a theoretical practice. Like the cyclical process of experiencing, thinking, and learning, Dewey admired how education is by nature an endless circle or spiral. In its very process it sets more problems to be further studied, which then react into the educative process to change it still further, and thus demand more thought, more science, and so on, in everlasting sequence.[9] Done correctly, the education system could offer an amalgamation of experiences, where people can compare knowledge, experience things together, and grow as intellectuals in a perpetual state of discovery. Dewey's proclamations and subsequent call for reform was one of the major catalysts for the revision of major educational theories, leading to a much more complex understanding of the physical process of learning. Among those leading the charge many decades later was Harvard University Professor of Education Dr. Howard Gardner with his theory of multiple intelligences.

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[7] John Dewey, *Art as Experience* (Balch, 1934), 104.
[8] Arthur Zilversmit, *Changing Schools: Progressive Education Theory and Practice, 1930-1960* (University of Chicago Press, 1996), 5.
[9] John Dewey, *The Sources of a Science of Education* (Horace Liveright, 1929), 77.

Traditional schooling and test taking favored certain students, while others, no matter how intelligent or capable, could not succeed under these circumstances. It was not until educators like Gardner delved into the idea that people have different styles of learning as well as stages of intellectual development that overall methods of education and engagement could be improved. Building off of the philosophies of John Dewey and others, Gardner developed a methodical theory that explained several different ways in which people can obtain and retain information, implying that a singular avenue of education would be inefficient for the general population, and that diversity in information implementation was the key to tap into as many intelligences as possible. Gardner observed that as our understanding of the human brain and nervous system advanced, so too should our methods of defining and measuring intelligence. Gardner brought to light the realization that educators were at a crossroads: either to continue with the traditional views of intelligence and how it should be measured or to come up with a different, and better, way of conceptualizing the human intellect.[10] Tasked with creating an updated definition to better reflect the current understanding of the mind, Gardner conceptualized an **intelligence** as a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value to that culture.[11] This new definition proposed that intelligence was not directly linked to a physical skill, such as memorization, or a specific subject, like mathematics or physics, but rather, was a *way* in which someone could process information, solve problems, and produce results. Gardner elaborates by explaining that intelligence should be thought of as entities at a certain level of generality, broader than highly specific computational mechanisms (like line detection) while

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[10] Howard Gardner, *Intelligence Reframed: Multiple Intelligences for the 21st Century* (Basic Books, 1999), 3.
[11] Ibid., 33.

narrower than the most general capacities, like analysis, synthesis, or sense of self.[12] This meant that just because someone couldn't perform a specific task, like completing a standardized test, mastering a musical instrument, or rowing a canoe, did not reflect negatively on their overall ability to learn. The context and individual's role within that context is equally important. For example, in some situations it is better to know how to steer a canoe than play the piano. Furthermore, Gardner recognized several specific types of intelligences, namely: musical; visual-spatial; bodily-kinesthetic; intrapersonal; interpersonal; naturalistic; verbal-linguistic; mathematical-logical; and more. Gardner was adamant in his research about there being an infinite number of types of intelligences, as well as the fact that people were not and should not be defined by a single intelligence. Instead, we all have varying degrees of different intelligences that we would use depending on the specific task. For example, some people learn new vocabulary through song, while at the same time understand chemistry through visual representations of elements, but prefer to speak to another person or read books when learning a new language. Everyone has varying strengths and preferences of learning styles that are dependent on what they're trying to learn. Oftentimes people do not know which type of intelligence or what combination of them will best serve to transfer knowledge and understanding of concepts, which is why it's so critical to provide multiple avenues for people to explore. Thus, the theory serves as an endorsement of three major points that further the notion of intellectual diversity and overlap. First, we are not all the same. Second, we do not all have the same kinds of minds (that is, we are not all distinct points on a single bell curve). Finally, education works most effectively if these differences are taken into account rather than denied or ignored.[13] Gardner connects these multiple intelligences to schools and other educational

[12] Howard Gardner, *Frames of the Mind: The Theory of Multiple Intelligences* (Heinemann, 1983), 68.
[13] Ibid., 91.

institutions by advocating for a diversity of learning styles to engage as many people as possible in as many ways as possible. The argument is that retention of knowledge and skill is increased when the same content or skills are learned through multiple methods. A monochromatic approach that adopts one pedagogic strategy is overwhelmingly at odds with the empirical reality of students' multiple intelligences, different models of information processing, and variety of culturally preferred learning styles.[14] By this logic, Gardner reasons that at a theoretical level, all individuals cannot be arrayed on a single intellectual dimension. At the practical level, it suggests that any uniform educational approach is likely to serve only a small percentage of children optimally.[15] This logical breakdown would explain why students seem to randomly excel in certain classes while they severely struggle in others. Students and people in general are not simply "smart" or "dumb", nor are they exclusively "visual" or "auditory". People have a wide variety of intelligences that allow them to learn more information. If one method is unsuccessful, another might prove incredibly helpful. This is why diversity of education methods is so critical to student success. Teachers might lean heavily on a specific type of intelligence- for example logical/mathematical- that has proven useful to them, even if it isn't helpful to their students. It is impossible to know what method will work for what information for each person, so designing education in a way that prepares for simultaneous stimuli and learning styles will produce the best results.

Luckily, this theory is supported by a plethora of environmental observation, experiments, and scientific progress in physiology. Dr. Stephen Brookfield spent twenty years collecting data from students across multiple disciplines and institutions regarding their reactions

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[14] Alison James and Stephen Brookfield, *Engaging Imagination: Helping Students Become Creative and Reflective Thinkers* (John Wiley & Sons, 2014), 6.
[15] Gardner, *Intelligence Reframed*, 91.

to classroom learning. His anonymous student response form, the Critical Incident Questionnaire, specifically asks students to identify moments where they were most and least engaged as learners, and actions that helped or hindered this engagement. Repeatedly, students say that the classes where they were most engaged were those where three or four different teaching modalities of learning activities were used.[16]

Our current understanding of human physiology greatly supports these theories. It is relevant to this argument to have a clear understanding of how the nervous system and brain interact to comprehend how external information is received, processed, stored, and interpreted. The control center of the nervous system is the brain. In *An Introduction to Brain and Behavior*, the brain is defined as an organ of soft nervous tissue contained in the skull of vertebrates, functioning as the coordinating center of sensation and intellectual and nervous activity.[17] The brain, in conjunction with the spinal cord, make up the central nervous system, and all the nerve fibers radiating out beyond the brain and spinal cord as well as all the neurons outside the brain and spinal cord form the peripheral nervous system.[18] Information retrieved from sensory receptors in the skin, muscles, and internal body organs all send signals back through the nervous system to the brain, where they are then processed through the thalamus. The thalamus is defined as part of the diencephalon through which sensory impulses pass to reach the cerebral cortex.[19] This is the universal model for all sensory information, although their specific physical locations are separated throughout the brain (see Figure 1, Appendix B). The key element of the nervous system is the presence of neurons, or nerve cells, which are uniquely designed to gather

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[16] James, *Engaging Imagination*, 9.
[17] Bryan Kolb, Ian Q. Whishaw, and G. Campbell Teskey, *An Introduction to Brain and Behavior* (Macmillan Education, 2016), 4.
[18] Ibid., 36.
[19] Ibid., 60.

information. In addition to features common to all cells, such as a nucleus, neurons have specialized projections, known as nerve fibers (axons) that carry nerve signals.[20] They are integral to human existence, due to the fact that they encode memories and produce our thoughts and emotions. At the same time, they regulate body processes such as breathing, heartbeat, and body temperature, to which we seldom give thought.[21] These systems are important because of the phenomena known as neuroplasticity, which is defined by the *Oxford Dictionary* as the ability of the brain to form and reorganize synaptic connections, especially in response to learning or experience or following injury.[22] Neuroplasticity is not only a requirement for learning and remembering, but a characteristic that is observed across all species of animals, from large, complex mammalian brains to that of a worm. Animals with larger brains naturally have more neurons, and therefore more synapses. The *Merriam-Webster Dictionary* explains that a synapse is the point at which a nervous impulse passes from one neuron to another.[23] The synapse provides a site for the neural basis of learning, a relatively permanent change in behavior that results from experience.[24] Therefore, the process of all learning from a biological viewpoint is the growth and development of neurons and synapses. An animal's perception of the world depends on the complexity and organization of its nervous system.[25] Humans' larger, more complex brains have greater capabilities for learning through neuroplasticity. This explains why we have creative, in depth perceptions of the world (see Figures 2-3, Appendix B). Through

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[20] Aviva, "Structure and Function: Nerve Cells," Medical Encyclopedia - Structure and Function: Nerve Cells - Aviva, 2017, https://www.aviva.co.uk/health-insurance/home-of-health/ medical-centre/medical-encyclopedia/entry/structure-and-function-nerve-cells/

[21] Kolb, *An Introduction to Brain and Behavior*, 77.

[22] Oxford University Press, "Neuroplasticity | Definition of neuroplasticity in English by Oxford Dictionaries," Oxford Dictionaries | English, 2017, https://en.oxforddictionaries.com/definition/neuroplasticity.

[23] Merriam-Webster Incorporated, "Synapse," Merriam-Webster, 2017, https://www.merriam-webster.com/dictionary/synapse.

[24] Kolb, *An Introduction to Brain and Behavior*, 164.

[25] Ibid., 284.

bodily sensations like touch and balance, in addition to auditory, visual, and chemical sensations, like taste and olfaction, we connect to and interact with the rest of the world. Our countless experiences in turn endlessly develop our neurons and synapses to allow us to increase our ability to learn, comprehend, and remember. **Multisensory**, then, is the simultaneous activation of these sensory organs. Truly ahead of his time, Dewey predicted and theorized what we now define as neuroplasticity, and was correct in his hypothesis that engaging with the environment through direct experience is how humans best discover and understand the world around them. Dewey and Gardner's theories are further supported by a wide variety of experiments that revealed how significant engaging with a multisensory rich environment affect organisms' ability to learn and overall quality of life. In 1947, scientist Donald Hebb used lab rats to compare the effects of enriching the senses, and how to stimulate animals' brains by housing them in environments that provide sensory or motor experience.[26] One group of rats lived in cages in his laboratory, while the other group had the use of his entire kitchen, allowing for multisensory stimulation of touch, smell, vision, hearing, and taste. He then had the two groups compete through a series of mazes. His experiments documented how the enriched animals performed better, and Hebb concluded that one effect of the enriched experiences is to enhance later learning.[27] Similarly, in 1999, scientists Marian Diamond and Janet Hopson conducted multiple experiments over several years, and found that animals (rats, cats, and monkeys) raised in sensory-rich environments developed higher levels of intelligence and lived longer than animals raised in sensory-deprived environments. Furthermore, the physical brains of the animals in sensory-rich environments were larger and healthier than the brains of animals raised

[26] Kolb, *An Introduction to Brain and Behavior,* 507.
[27] Ibid.

in sensory-deprived environments.[28] Based on Hebb's original research, these findings strengthened the understanding that the link between sensory processing and brain development in humans and animals develops in accordance with the quantity, quality, and nature of the stimuli in the environment.[29] Consistently interacting with the environment in ways that elicit the senses and multiple intelligences is directly linked to the physiological phenomena of comprehension, and the intellectual potential and overall health of the brain. Animals, humans included, physically benefit from exercising their multiple intelligences, and increase their ability to continue to learn when they do so. This research is critical to the progressive education movement and my argument that makerspaces are educational tools. It substantiates the theories and observations of these educators by cementing them in scientific evidence.

These educational theories can and should be considered in the art museum world. Traditionally, art museums have focused on collecting and art historical scholarship, not the visitor experience (nor do they study their visitors' behavior or interactions). Now, thanks to decades of observations, focus groups, and experiments, it is clear that the methodology behind the aforementioned educational theories applies to the informal learning environment of an art museum. One of the most significant voices bridging educational theories and museum visitor prioritization is Lesley College Professor George Hein. Hein has not only considered the many varieties of museum visitors, but how they learn in this setting, what interests them, and the techniques and decisions museum educators and exhibit designers in a variety of museums can make that determine a museum's success or failure at conveying specific information or a desired perspective. The major concept behind this style of thinking and programming is referred to as constructivism.

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[28] Ibid., 23.
[29] Ibid.

Constructivism is a well-established theory of learning indicating that people actively construct new knowledge by combining their experiences with what they already know. New knowledge results from the process of making sense of new situations by reconciling new experiences or information with what the learner already knows or has experienced. This profoundly personal process underlies all learning.[30] Constructivist environments scaffold thinking and actions in order to deepen understanding. **Scaffolding** is conveying information in a layered way so visitors can use it as a guide as they progress in a project, referencing the information as needed, not needing to constantly use all of the information at once, while simultaneously not being abandoned or lost by a total lack of helpful information. They provide opportunities for learners to amplify and extend cognitive capabilities, as well as reorganize thinking processes by altering the task available to them.[31]

In conjunction with constructivism, collaboration is a powerful form of learning. Collaboration gives students the opportunity to discuss ideas and flesh out concepts through an iterative and evaluative process. Collaborative learning generally takes the form of group work, but can be categorized as any exploration of an idea with two or more minds involved. Individuals working in groups generally retain more information and understand a concept more fully than those working alone.[32] Instead of teaching *at* a person, constructivism supports the idea of assisting learning through trial and error. Educators become facilitators instead of lecturers, and act as resources in a student's personal learning journey.[33]

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[30] Sylvia Martinez and Gary Stager, *Invent to Learn: Making, Tinkering, and Engineering in the Classroom* (Constructing Modern Knowledge Press, 2013), 31.
[31] Pea, R. (1985) Beyond Amplification: Using the Computer to Reorganize Mental Functioning. Educational Psychologist, 20(4), 167-182.
[32] Ellyssa Kroski, *The Makerspace Librarian's Sourcebook* (ALA Editions, 2017), 31.
[33] Ibid., 33.

Through his research at museums like The Exploratorium, Hein developed an in-depth understanding of how visitors move through museums, and more importantly how they learn. Understanding group dynamics, the importance of interactivity, and the powerful social function of museums can make a significant difference in the likelihood that the goals of the education programming are received and retained by the audience. The value of allowing visitors to interact with exhibits in museums was first documented by Yale University Psychologist Arthur Melton (1936), who demonstrated that average time spent at an electricity exhibition at a science museum went from 13.9 to 23.8 seconds when visitors manipulated components.[34] Hein's work is important to art museums because it tackles many elements of the museum experience that are not typically perceived as high priority for art exhibition and programming designers, but are vital for a successful museum experience.

Comfort is a necessary, although not sufficient, element for learning in museums. Visitor comfort covers a wide range of factors, from simple physical comfort (convenient facilities, places to rest), to psychological conditions, such as the discomfort humans experience when they face away from open spaces, as they often do in museums, to the inevitable "museum fatigue," first described by Boston Museum of Fine Arts Educator Benjamin Ives Gilman (1916) that sets in after approximately half an hour of exhibition viewing.[35] Similarly, the differences in how children, teens, adults, and ultimately families navigate the space are very different due to their differences in development and life experiences, so catering to these different levels makes a difference in terms of programming success. Children generally experience a sense of powerlessness in museums, as they do in many aspects of their lives. Unlike other age-groups, they are rarely in museums by free choice. Offering children choices during museum visits, such

[34] George Hein and Mary Alexander, *Museums: Places of Learning* (Technical Information Service, 1998), 16.
[35] Ibid., 11.

as allowing them to choose a work of art on which to focus can give them some feeling of power and command over their museum experience.[36] Teenagers visit museums for very different reasons and behave similarly to family groups, making for easier programming design to appeal to both groups at once. It is in their peer groups that teenagers develop a sense of themselves as individuals. Museums are also viewed as places in which to socialize with friends. In fact, visiting museums without friends holds little interest for them. Over two-thirds of teenagers interviewed in a Brooklyn Museum study were significantly more interested in museum visits when they could attend with friends.[37] When asked what they did like about museums, teenagers in the study stated that museums gave them opportunities to "have conversations about important issues" and to "absorb ideas about other cultures into our own thoughts."[38] Perhaps most of all, teenagers want and need opportunities to learn in ways that support their self-esteem and growing individuality. This is why makerspaces are ideal for teen visitors. They are easy to design to accommodate groups, they allow for rapid prototyping and freedom of expression and experimentation without fear of failure, and allow for independence and creativity. Likewise, family groups use museums as social experiences in which they hope to learn. Accounting for the many different groupings of humans that make families is critical for programming, since the group will most likely make decisions together, meaning that if certain potential family members like small children or grandparents are ignored, the group as a whole might forfeit the programming. Families follow purposeful but personal agendas in which social interaction is a key element. "Family groups," usually defined as any multigenerational social group of up to five or six people who visit as a unit, make up a majority of casual visitors to museums.[39] Taking

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[36] Eilean Hooper-Greenhill, *The Educational Role of the Museum* (Routledge, 2007), 112.
[37] Ibid., 113.
[38] Ibid.
[39] Hein, *Museums: Places for Learning*, 22.

everything into consideration, the task becomes designing a space and/or programming that is an inviting, engaging, open-ended learning space. Unlike traditional staples of art museum education programming, such as lectures, docent-led tours, and didactic labels, makerspaces are unique in that they actively embrace the teachings of the progressive educators, making them ideal candidates to attract the largest percentage of visitors by conveying information effectively.

Makerspaces are about providing tools and materials to encourage a maker mindset focused on creativity.[40] Instead of fostering a singular conclusion arrived at by following one path, makerspaces provide the tools and scenarios for individuals and groups to experiment through many types of intelligences and viewpoints, without fear of failure since there is no correct or incorrect conclusion. Makerspaces encourage participants to fail, test boundaries, and explore creative limits in pursuit of intellectual growth and understanding. These spaces encourage collaboration and shared excitement, reinforcing project-based and collaborative learning in a space that is entirely directed and inspired by whatever a curious mind can concoct.[41] The final product is not the significant takeaway, but rather, the different strategies and ideas that culminate the journey. Putting people in the position of becoming makers instead of takers makes them aware of the choices that go into creating what surrounds us. Instead of telling visitors what to learn, hoping they take something away and deeming them “failures” if they don’t “succeed”, makerspaces present a specific scenario with specific resources, then shift the control into the hands and minds of the visitors, encouraging a plethora of conclusions and understandings. Although visitors might take drastically different journeys and arrive at different solutions, the overarching learning outcomes and lessons can still translate universally. Makerspaces provide the opportunity to have an authentic, personal experience with new

[40] Graves, *Challenge-based Learning in the School Library Makerspace,* 1.
[41] Kroski, *The Makerspace Librarian’s Sourcebook*, 33.

concepts and material as Dewey encouraged, in order to promote deep learning and meaning. When a visitor has solved an issue by creating something of their own, the lesson is retained and given significance through the physical experiences of entering the space, interacting with the resources, thinking, and ultimately creating something purely out of their own mind. Even in a group, individuals still contribute personal knowledge that contributes to the conclusion, and impacts the group members as a social activity that for some people is more interesting and memorable than being in a group, lecture, or tour.

Makerspaces also support Gardner's multiple intelligence theory because they provide opportunities to explore issues through a wider variety of intelligences than traditional programming. In the same makerspace, a museum could provide physical tools, visual examples, audio, and even music, to entice a wider audience with different intellectual learning styles and preferences. Because the final product is open, visitors can choose what learning styles they'd prefer to activate, or explore the given scenario through each type of intelligence to see what different conclusions they arrive at, all of which would be valid. Makerspaces also adhere to the many observations of George Hein, and have the ability to quickly and easily change and adapt depending on the goals of the programming. It would be easy to design a makerspace with designated sections to invite individual learners, groups, or families, and allow them a physical space to enter and utilize without feeling totally isolated from the rest of the museum.

A final point is the value of accessible design and content for all audiences. An effective makerspace benefits all visitors, because everyone has a particular combination of intelligences and preferences and benefit from a diversity in engagement, but it also provides learning opportunities for people with special needs, who might be shut out of most other kinds of programs. Whereas the traditional art museum education programs mentioned earlier usually focus heavily on one or two types of intelligences and learning styles, makerspaces ideally provide a base for curiosity and learning for anyone. This is the key advantage the makerspaces can provide to art museum education programming. They can help the museum achieve greater educational goals while simultaneously bringing in much larger and more diverse audiences.

Chapter 3: Project Proposal

In the previous chapter, I discussed different modalities of learning and the evolution of Progressive Education theories through three key theorists; John Dewey, Howard Gardner, and George Hein. This foundation is the base for the potential of a makerspace as an educational tool. In this chapter, I propose four key terms that emerge from these theories and define successful visitor learning. By comparing real museum examples with the design and implementation of a makerspace, I hope to show how a makerspace is an efficient and effective culmination of these terms, which is why I believe it should be utilized by art museums as an additional education programming tool.

I have derived four key terms connected to successful visitor learning from my research as well as my experience in museum education and program development: 1. multiple intelligences, 2. direct experience, 3. inquiry based and open ended learning, and 4. dynamic physical space. I define a **makerspace** as a dynamic physical space where intellectual scaffolding is used to promote educational engagement through open ended and inquiry based learning. By adhering to this definition and implementing specific physical characteristics, I advocate that a makerspace can effectively fulfill the key terms simultaneously. In relation to my definition of a makerspace, it is important to first review the concepts of intellectual scaffolding and educational engagement.

As explained in the previous chapter, intellectual scaffolding conveys information in a layered way. Visitors can use it as a guide as they progress in a project, referencing the information as needed, but not needing to constantly use all of the information at once, while simultaneously not being abandoned or lost by a total lack of information. If the invitation to creativity is accompanied by intentional structure and guidance, maker activities can be channeled to support deep learning.[42] The opposite of intellectual scaffolding would be providing supplies in an otherwise empty room, with no context, no premise, and no guiding questions or helpful tips. When a space is set up in this way, it only elicits participation from highly inquisitive, confident and self-sufficient visitors, which is likely a small percentage of guests. This type of haphazard design communicates a sense of afterthought or low priority for the museum, and might feel daunting or confusing to visitors, kind of like telling someone who has never been to your home to open your refrigerator and fix a meal. There should always be a specified scenario or premise with intentional materials. Included in intellectual scaffolding is the importance of showcasing a wide variety of examples of possible outcomes. When there are no examples, visitors can feel intimidated or lost, unsure of the restraints of the space. If all of the examples displayed are very similar, visitors will assume they are expected to replicate the generic outcome. By showcasing a myriad of valid products, be they large, small, brightly colored, structurally sound, or abstract, visitors will have a better understanding of the open ended solutions they can arrive at, while also feeling encouraged to explore their ideas without scrutiny. A prime example of this is the “Create Your Own Bug” activity used by the Chabot Space and Science Center in Oakland, CA (Chabot). This activity provides visitors with varied craft supplies (popsicle sticks, colored pipe cleaners, cotton balls, googly eyes) and asks them to create a bug. There are no limitations on what one can create, and a board of bugs is used to showcase the variety of possibilities (see Figure 4, Appendix B). Chabot uses intellectual scaffolding to help visitors think critically about their creations, resulting in creative biological explanations. For example, “why did you make your bug this way?”, “where does your bug live and why?”, “What and how does your bug eat?”, “If the environment changed, how would your

[42] Sheninger, Eric C. *Uncommon Learning: Creating Schools That Work for Kids.* (Corwin, 2016), 78.

bug be affected?", and so on. A bug with no eyes and huge wings might use echolocation and live in the rainforest treetops. Alternatively, a bug with twelve legs might use them to climb its natural mountain habitat, protected by its pipe cleaner fur. The point is not to create the "best" or "correct" bug, but to experiment with choices and their consequences to better understand real insect anatomy, and the evolutionary relationship between organisms and their environment.

I am defining educational engagement as visitor engagement with defined educational outcomes. While pure socializing and having fun are important aspects of a visitor's overall museum experience, they are not the goals of a makerspace. Rather, a makerspace allows visitors to socialize and have fun *while* they learn. A space that does not have definable educational outcomes can appear to be more in line with a playground or game. Examples of fun and engaging yet educationally-inactive spaces include for-profit ventures like Museum of Ice Cream, the Color Factory, Candytopia, etc. These are spaces to socialize and Snapchat, but they do not define educational outcomes, like exploring the process of making ice cream, the chemical components of different candy types, or the photographic process of the selfie. They also have no intellectual scaffolding, meaning they lack labels, explanations, scenarios, prompts, or questions intended to steer visitors towards a fun educational journey, but simply a fun journey. Having defined educational outcomes is a requirement for a successful makerspace, and accomplishing them is the goal.

Key Term: Multiple Intelligences

As discussed in the previous chapter, Howard Gardner's theory of multiple intelligences centers around the idea of intelligences (visual, auditory, musical, mathematical, logical, etc.), and how everyone possesses them to varying strengths depending on the specific task at hand.

Because this concept is so crucial to the modern day understanding of how people learn, it is imperative that a modern day educational tool recognizes and supports it. Museums can and have offered successfully engaging combinations of multiple intelligences through multisensory activity. Spaces that are equipped to present the same information simultaneously through different activities that prioritize different senses and intelligences are able to reach the largest number and diversity of visitors. Organizing activities in this way helps combat circumstantial obstacles like age, education, or intellectual development, which might otherwise prevent the visitor from participating. Ideal examples of this key term readily seen in museums are participatory exhibition designs. Participatory exhibitions have elements that position the visitor as an active contributor as well as information recipient. They provide alternative methods for exploring the same information to encourage deeper learning, which is the desired outcome when strategizing about visitors' multiple intelligences. During the Oakland Museum of California's *RESPECT: Hip-Hop* exhibition in 2018, different stations were used to help illustrate the complexity and creativity involved in creating hip hop music, including interactive turntables, freestyling and beatboxing areas, as well as quiet reading areas and places where visitors could don headphones and listen to hip-hop. This array of activities had the same defined educational outcome - learning about the complex artistry of hip-hop - but provided varied ways for visitors to accomplish them by catering to the multiple intelligences, such as kinesthetic, musical, and logical-mathematical.

Likewise, makerspaces allow visitors to listen, look, touch, talk, move, and collaborate with the presenter as well as each other, encouraging people to combine their different learning skills and strengths to come to a wide variety of conclusions. Alternating verbal and visual modalities, silent and oral ways of communicating, individual and group activities, kinesthetic and cognitive activities, and abstract and concrete ways of processing information keeps the activity moving as it calls on different elements of students' personalities and skill sets.[43] Several successful multisensory art museum examples of this key term exist. Tate Britain's 2015 exhibition *Tate Sensorium* used multisensory tools to engage with visitors with and without physical disabilities, including edible charcoal, industrial sounds, and scents of grass and oil to showcase Francis Bacon's *Figure in a Landscape* (see Figure 5-6, Appendix B). Tate Sensorium won the IK Prize 2015, which is "awarded annually for an idea that uses innovative technology to enable the public to discover, explore and enjoy British art from the Tate collection in new ways."[44] Another example is the Guggenheim's exhibition *The Touchy Subject*, which collaborated with blind artist Carmen Papalia to lead visitors on a tour where they could not see. This exhibition was also well received. In exit interviews participants described how they "spoke not of loss or limitation, but rather mobilized states of attention and insight."[45] The Louvre produced a similar exhibition titled *The Touch Gallery: Sculpting the Body,* where visitors traveled down an outlined path that showcased 18 different casts of works ranging from ancient to modern techniques that were available to touch, so visitors could use a combination of senses to understand how sculpture had changed over time. The exhibit was so successful that "the display of casts and sculptures in the Touch Gallery has been renewed for the sixth time since it opened in 1995."[46] A fourth example is the Metropolitan Museum of Art's exhibition *The Multisensory MET* which incorporated several multisensory aspects into the galleries, including

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[43] James, Alison, and Stephen Brookfield. *Engaging Imagination: Helping Students Become Creative and Reflective Thinkers*. (John Wiley & Sons), 2014, 9.

[44] Tate, "IK Prize 2015: Tate Sensorium," Exhibitions and Events, 2015, http://www.tate.org.uk/whats-on/tate-britain/display/ik-prize-2015-tate-sensorium.

[45] Georgia Krantz, "How Do You See a Museum with Your Eyes Closed?" Guggenheim, March 29, 2017, https://www.guggenheim.org/blogs/checklist/how-do-you-see-a-museum-with-your-eyes-closed.

[46] The Louvre, "Touch Gallery: "Sculpting the Body", Louvre Museum, Paris, 2006, http://www.louvre.fr/en/tactile-gallerya-new-tour-sculpting-body.

replicas, scented oils, and touchable samples of materials of works on view. Although the exhibition was well received by the general public, it was especially appreciated by visitors with visual impairments, who are otherwise excluded from a majority of museum collections, most of which cannot be touched but are otherwise exclusively visual. Dan Burke, a visitor who is blind, spoke positively of the exhibition and how “it is a very moving experience when you recognize a piece or feel an emotional connection to new art.”[47] He went on to describe his “intense flood of inspiration” he felt when touching *Pacific Giant*, a large bronze octopus sculpture. While none of these examples are of makerspaces, they are all examples of art museums successfully incorporating multisensory elements into their design and programming to activate visitors’ different capabilities and multiple intelligences, in order to have a deeper understanding of the pieces.

As evident in these examples, humans enjoy exploring their surroundings through kinesthetics, discovering and investigating by touching, breaking apart, and reconfiguring. Touch is the first of the senses to develop in the human infant, and it remains perhaps the most emotionally central throughout our lives.[48] Clear evidence of the power of touch to arouse sensory curiosity is found wherever a bronze sculpture is placed within visitor reach, whether it is Brighty the burro, displayed at the North Rim Lodge at the Grand Canyon, or Bob Newhart at the entrance to Navy Pier in Chicago.[49] It is because of this inert need to understand through physical contact that museums must protect their artifacts with Plexiglas, signage, security staff, stanchions, and even invisible lasers. Consequently, museums, especially art museums, can

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[47] Jacoba Urist, "A New Way to See Art," The Atlantic, June 08, 2016, https://www.theatlantic.com/health/archive/2016/06/multisensory-art/486200/.

[48] Maria Konnikova. "The Power of Touch." June 19, 2017. https://www.newyorker.com/science/maria-konnikova/power-touch.

[49] Deborah L. Perry. *What Makes Learning Fun?: Principles for the Design of Intrinsically Motivating Museum Exhibits*. AltaMira Press, 2012.

develop a stigma of being uninviting, “do not touch” galleries that frown upon kinesthetic learning, when in reality they are simply and justly taking serious the preservation of their collection. This is where makerspaces can be especially useful to art museum education programming. Without risking any of the actual works or investing in realistic replicas, makerspaces fulfill visitors’ needs to touch and explore while still learning the concepts presented through the original pieces. Visitors can pivot between the art and the makerspace, satiating their desire for physical contact without increasing risk to the collection. Exhibitions like the ones previously described are examples of kinesthetic and multisensory elements placed directly within gallery space. They are innovative examples of how to convey actual pieces to visitors, both with and without learning disabilities. Alternatively, a makerspace is a tool to engage in defined education outcomes connected to those pieces, to further the conversation, exploration, and reflection or overarching artistic and educational themes, without physically occupying gallery space. I believe that makerspaces can be complimentary additions to these types of exhibitions, and practical alternatives for museums unable to accommodate in-gallery experiences.

Key Term: Direct Experience

Integral to successful visitor learning is the opportunity to have a direct experience. As explored in the theories of John Dewey, the essence of “experience” is that it is personally engaging or meaningful. Likewise, museum theorist Lois Silverman’s research into the social work of museums highlights the process of meaning-making by visitors, and how the accessibility and combination of objects and programming positions museums to specialize in opportunities for meaning-making.[50] To reiterate museum marketing expert Neil Kotler's definition, experiencing connotes active engagement (direct observation of or participation in an event), immediacy (knowing something through sensory stimuli), individuality (something that is lived through), and intense, memorable, or unusual encounters.[51] Depending on a museum's collection, it can be difficult to provide a direct experience with pieces beyond sight. Similarly, it is not realistic to reenact wars or time periods to invoke a direct experience if the organization is not already equipped to facilitate it, like living history museums. Some museums have had single days or festivals to provide direct experiences related to their collections, like the San Francisco Legion of Honor's "Victorian Visions" events where visitors are encouraged to come in full costume indicative of the museum's collection. For an everyday approach to direct experience, especially one that does not require visitors to bring supplies or risk supplies being in close proximity to pieces, makerspaces can be an ideal tool. One example is the Denver Art Museum's makerspace programming in conjunction with their 2016 exhibition *The Western: An Epic in Art and Film*. This makerspace programming allowed visitors to learn about the physical process of costume design, artistic decision making related to traditional Western film costumes, and then create their own at separate workstations. All of these activities compliment the exhibition without directly interfering with gallery space, and provide different opportunities for direct experiences with materials and processes. While it is important to be introduced to new concepts as explained verbally by experts, like one would be through a lecture, panel, tour, or label, it is crucial for visitors to be able to experience information for themselves in order to categorize it and contextualize it in their individual mind and interpretation of the world around them. An important idea from developmental psychology is that interaction is the most powerful mode of

[50] Silverman, Lois H. *The Social Work of Museums.* London: Routledge, 2010. 62.
[51] Neil Kotler, "Delivering Experience: Marketing the Museum's Full Range of Assets," Museum News, 1999, 32.

learning. Interaction is the opposite of passivity. We do not simply bring experiences to the world, nor do we perceive what is there in pure form. We impose our experiences on the world, be it an object or another person. Knowledge is acquired in a continuous process of accommodating prior knowledge expectations and beliefs to new realities learned through interactive experiences.[52] If we want to learn a new skill, like playing an instrument or participating in a sport, we don't simply watch videos of people performing or listen to professionals discuss technique: we take lessons, practice, join teams, and directly learn through participation and experiencing it for ourselves. We learn by doing, transitioning the new idea or skill into a personal memory. Art museums could develop makerspace programming that puts materials directly into the hands of visitors, in order to emphasize artist technique, difficulty of material, color theory, and more. The likelihood that visitors would internalize and retain the information is higher than listening or witnessing alone. Makerspaces take the positive characteristics of preexisting educational programming and give them an established space in the museum to be visited and revisited, accumulating direct experiences to deepen the relationship of the visitor to the related artwork, the museum as a physical space, and the alternating defined educational outcomes.

Although not a required component of a makerspace or a direct experience, I highly recommend designing a makerspace that allows visitors to take home either their creation or a physical object representative of the defined educational outcomes and direct experience of that specific activity. While this raises concerns regarding budget, it has important educational benefits that help cement deeper learning and value of the direct experience to the visitor. By allowing visitors to take their creation home, several goals are accomplished. First, the visitor is

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[52] Eilean Hooper-Greenhill. *The Educational Role of the Museum*. (Routledge, 2007), 111.

more inclined to give genuine thought and effort to addressing and solving the problem presented because there is a physical, tangible product as the reward. They are not participating solely for participation's sake, but working towards a foreseeable object that will manifest through their direct participation. What's more, the object is a reflection of their individual creativity, knowledge, and skill set. Their creation is an extension of themselves, which is more meaningful than creating through mimicking or step by step instructions. The creative process of physically constructing an object is an effective way to both develop and demonstrate understanding. This possibility is preferred over take home items like handouts or instructions, because it grounds the object in the visitor's memory to a specific moment in time at that specific museum.

Key Term: Inquiry Based and Open Ended Learning

Although inquiry based learning and open ended learning are different concepts, they are closely related, which is why I have grouped them together. I**nquiry based learning** is the process of learning by posing questions, problems, or scenarios.[53] Similarly, **open ended learning** is the process of learning by prioritizing each individual's journey through a lesson, instead of prioritizing a singular specific outcome. When an activity is inquiry based, the progression of a visitor's individual path towards a museum's defined educational outcomes will be determined by their preferential curiosity, prior knowledge, and unique combination of multiple intelligences that best suit their needs for the task at hand. It is a reciprocal approach where the visitor receives the energy they put in to exploring the scenario and subsequent materials. Inquiry based learning aligns with Progressive Education theories because it does not dictate the path the visitor must take, but rather allows them to explore on their own, at their own

[53] Kroski, Ellyssa. *The Makerspace Librarian's Sourcebook*. (ALA Editions, an Imprint of the American Library Association, 2017), 32.

pace and according to their own interests. This contrasts to more controlled methods of imparting information like scripted audio tours and lectures. Like the traditional art museum audio tour, a lecture may serve as an example of a one-way flow of information where the ending has been predetermined and is only meant to be passively transferred to the visitor. Again, like audio tours, a discussion of which is beyond the scope of this capstone, modern lectures can and have shifted to transition from the expertise of the presenting scholar to an open discussion that advocates for diverse perspectives and open-ended conclusions, but this is heavily determined by the scholar, their topic, the information conveyed, the museum promoting the lecture, and the structure of the lecture. On the other hand, examples like the Chabot's "Make a Spaceship" makerspace activity illustrate how open ended learning promotes participation and exploration. Visitors are given LEGOS and other building material to craft spaceships which can then be tested on a zip line (see Figure 7, Appendix B). It is up to visitors how large, small, fast, slow, stable, or complicated their spaceship is. By allowing visitors to test their speed and durability on the zip line, visitors can see how their design compares to others, and learn what aspects of their design cause which affects (bulky spaceships are slower but more durable, smaller spaceships are faster but do not accommodate an astronaut, and so on). The fact that there is not a specific, singular outcome means there is little to no fear of failure, that is, not getting or arriving at the one right answer. As another example, if the objective is to create a disproportionate form out of cardboard to represent sculpting. Regardless of whether the visitor succeeds, they learn about the material, the struggle to balance weight throughout a form, the chemical elements that can affect their sculpture, as well as the techniques of the artist in question to be able to create the works on display. Putting people in the position of makers instead of takers makes them aware of all the choices that go into creating everything that surrounds us. Museums that take learning seriously can benefit from addressing their visitors as creators.[54] The goal is not to recreate a specific shape or follow a specified path, but rather, entice visitors to express themselves to create infinite solutions to a specified problem by learning about art.

Key Term: Dynamic Physical Space

A makerspace is not defined by how many chairs it has or if there is a 3D printer available. Every makerspace will be different, because every makerspace should be tailored to fit each individual institution and their defined educational outcomes. However, there are notable best practices that will substantially affect the approachability and usefulness of a makerspace, regardless of square footage or budget. It's important to have a designated space, however large or small, to be devoted exclusively to the makerspace. My definition for a dynamic physical space is one that guests can physically enter (as opposed to a mobile cart or online platform); that can be easily manipulated (movable furniture, universal seating); and that has organized, clearly defined, and intentional areas (workstations, supply stock, individual and group spaces). In other words, it is a discrete area within the museum that is inviting. When the access or intended audience of a space or program is unclear, visitors will be less inclined to explore it. If a space seems highly specific to a single audience, like a playroom for toddlers or adult lounge, visitors outside of that audience may assume they cannot or should not participate. Research has shown that parents' perceptions and awareness of opportunities to learn in museums, as well a parent participation during family museum experiences, significantly influences the potential for child and family learning.[55] When a space has clearly designated areas and a variety of stations,

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[54] Brad King and Barry Lord. *The Manual of Museum Learning*. (Rowman & Littlefield, 2016), 232.
[55] Kylie Peppler, Erica Halverson, and Yasmin B. Kafai. Makeology: *Makerspaces as Learning Environments (Volume 1)*. (Taylor and Francis, 2016), 16.

visitors can quickly assess their options and understand that the space is intentionally designed to accommodate a wide variety of visitors, increasing the chances that visitors will explore the space and participate in the activity. Even if a museum is piloting a program for several weeks, it's important to substantiate the makerspace with a fixed location. When activities vary in location depending on the time or day, they are not only disruptive for staff, but disorienting for visitors. The makerspace seems like an afterthought. Both science and art museums have found that secluded areas where visitors have a chance to interact with materials attract people and encourage them to spend unusually long time periods engaging in personal inquiries.[56] They are also easier to manage since supplies can be stored and staff know where to go to set up facilitate, and clean up.

Another critical component of a dynamic space is the flexibility of the furniture. When furniture is restrictive, the same issues of approachability previously described can happen. If seating is exclusively short or high, certain visitors are directly excluded. If seating is rigid like a traditional school desk which is permanently attached to a forward facing desk, visitors are less likely to maintain focus, or will shorten their participation as they become less comfortable. When seating can be easily rearranged, visitors can focus on the activity. Many children (and adults) are kinesthetic learners. They need to have some sense of movement, or they cannot focus. Fidgeting can actually stimulate the brain and prevent mental fatigue. Swivel chairs, chairs on wheels, and stools with uneven bases allow for wobbling. Many teachers have found success with exercise balls, as they are affordable and allow students to bounce slightly as they work.[57] Another key point about rearranging furniture is the invitation it provides for varied groups.

[56] George Hein, and Mary Alexander. *Museums: Places of Learning.* (Technical Information Service, 1998), 17.
[57] Colleen Graves, Aaron Graves and Diana L. Rendina. *Challenge-based Learning in the School Library Makerspace*. (Libraries Unlimited, an Imprint of ABC-CLIO, LLC, 2017), 39.

Visitors might have one partner of similar age, or several multigenerational group members. When seating is easily movable, it can quickly accommodate different group dynamics, allowing for greater participation from each member and a longer stay in the space overall. Tables with a central base are more dynamic than tables with legs, which usually only allow for a specific number of chairs in a single arrangement. A multifaceted permanent space with mobile workstations and seating will be able to attract and accommodate the widest variety of visitors (see Figure 8, Appendix B).

Similar to this point, an ideal makerspace should have regular drop in hours, preferably operating during the entire timespan when the museum is open. This sets up the space to be inviting and available to as many visitors as possible. It also allows the highest percentage of visitors to participate, since it would be available at any time during their visit, whether they can only come in the morning, afternoon, weekday, or weekend, depending on the specific museums' hours of operation.

Many studies show how visitors choose between competing elements in a museum, especially if they overlap in space or timing. If a makerspace is only open during certain hours or days, people are excluded. There may also be time conflicts with other activities like a planetarium show, animal viewing, art tour, curator lecture, or other program. With regular drop in hours, visitors don't feel pressured to make a serious commitment, while simultaneously understanding that if they'd like to spend an extended amount of time in the makerspace, they are able to. Visitors may choose the extent of their participation, allowing for visitors with varying schedules or restrictions to enjoy the makerspace. Visitors can drop in, explore the museum, and then come back, bringing elements of the recently visited galleries into their makerspace creations.

Another highly influential physical factor of a dynamic space is the degree to which it allows and promotes socializing. Many museums, especially art museums, provide space in and outside of galleries ideal for personal or intimate observation, reflection, and contemplation. These are important physical spaces where visitors can observe the collections at their own pace, and should have alternative social spaces. These different types of spaces do not and should not compete with one another, but rather, provide breaks from one another as opposing yet complementary atmospheres. It is important for visitors to be able to find space for quiet self-discovery, as well as socializing, and museums should try to include both to varying degrees. As explained in the previous chapter, the research of George Hein highlights how humans navigate museum spaces, and how heavily their ability to socialize influences their decision making.

A diverse portfolio of programming allows as many pathways as possible for different visitors to learn. It is difficult to adequately address multiple key points in a lasting way due to the complexity and commitment to the space it would require. Lectures, panel discussions and audio guides are successful methods for conveying information through one-way audio and visual representations, usually presented by an expert to a well-developed audience of adults. School tours are a longstanding method employed by every type of museum to expose younger audiences to new knowledge, that allow for varied levels of socializing, and may include hands on activities. These are important staples of museum education, including art museums, but they are not designed to intentionally address these modern four key terms indicative of successful visitor learning. Rather than shut down or transform these important methods of information presentation, art museums should consider adding a makerspace to fill this niche. The makerspace will not be for every visitor, which is why I suggest teaming it with well-established methods. Some visitors will prefer sitting in a lecture or listening to a docent or audio tour over being challenged to create or handle materials. The makerspace is, however, an ideal form of programming to prioritize these four key terms, and to reach the most visitors with the highest diversity in intelligences, intellectual development, groupings, and learning styles. By providing the community with space and tools, the museum becomes not just a learning institution but a learning platform.[58]

Making the Ideal Makerspace

As stated above, every makerspace should be tailored to the institution creating it. One of the best aspects of makerspaces is that no two are exactly alike. However, there are specific components to which every physical makerspace should adhere regarding design and implementation. I propose several steps and guidelines museums can follow to begin their journey towards an, effective, functioning makerspace. These guidelines can be used if an institution is considering a pilot program of several weeks, or a permanent space in their building. Overall, these guidelines serve to ensure a makerspace can accomplish the four key terms that I outlined above.

Intention of a Makerspace

The primary goal of any makerspace, regardless of size or institution, is to promote educational engagement. If an institution designs a makerspace with a different primary goal, like generating revenue or providing a rest stop, their outcome might be popular or well received, but it will not achieve the four key terms; it will not transfer the defined educational outcomes of the institution; and it will not be a makerspace. Makerspaces have the potential to generate

[58] King, *The Manual of Museum Learning*, 233.

revenue or attract visitors for reasons other than learning, but these are not the intended purpose and should not be prioritized when designing a space. Regardless of the defined educational outcomes articulated by the institution, the idea that the makerspace is a dynamic physical space that promotes direct experience, multiple intelligences, and uses open ended and inquiry based learning should always be present.

Leadership

The specific leadership spearheading a makerspace will again vary by institution, but to be effective the makerspace must have buy-in at the highest level of the museum, namely the director. Once the director's support is solid, since the primary goal of a makerspace is education, the core team leader of any makerspace should be a part of the education department. Ideally, several people will be involved in a collaborative team to design the physical space, create content and defined educational outcomes, train staff, choose appropriate supplies, maintain the space, and evaluate its effectiveness. Whenever possible, it is important to have input from different departments or people with different learning styles and experience, to evaluate the diversity of the makerspace. If everyone involved has highly similar learning styles or the same training and experience, it is likely the makerspace will reflect that, and unintentionally lack opportunities for diverse audiences to engage. It is essential to understand the demographic of your institution's current visitor population versus the population of your institution's community, to see who does and does not frequent the space. For example, if five percent of visitors to your museum are families with children aged 5-10, but the population of the city is eighty percent families with children aged 5-10, there is clearly a disconnect with the community and your institution, and the makerspace can be an opportunity to provide programming suitable for new audiences. Similarly, if the current education programming is almost exclusively audio tours, lectures and/or visual presentations, your makerspace could help fill the need for kinesthetic, social musical, and naturalist learners who aren't candidates for your current programming. The plasticity of a makerspace is why it can be used to help increase engagement for a variety of situations, while still including current visitors. Even if the staff responsible for the makerspace all come from within the education department, it would be strategic to incorporate opportunities for feedback from other departments, so that the space can be interpreted by a variety of minds, which is what would happen regularly once the makerspace is operational and open to the public.

Defined Educational Outcomes

Because the primary objective of a makerspace is educational, there should always be defined educational outcomes that drive the specific scenarios. Every institution can have overarching educational goals similar to their mission statement, such as "teach visitors about contemporary art" or "help visitors explore nature", but defined educational outcomes need to be more specific. Defined educational outcomes should be specific to each scenario enacted in the makerspace, so that as the outcomes change, the makerspace shifts to complement them. For example, if an institution is interested in relating their makerspace to a current exhibition on Surrealism, a defined educational outcome could be "to help visitors explore characteristics of surrealist art". From this, the leadership team can break down their ideas into questions like "What is Surrealist art?", "What makes it different than other styles of art?", "What different activities can visitors use to learn the different characteristics?", and so on. Now, the specific stations of a makerspace can be designed. These may include visual examples of pieces from the exhibition, interactive workstations to create your own surrealist art with different prompts for each characteristic, games to identify and differentiate different characteristics, and audio and music related to surrealist art. If the defined educational outcome changes to “for visitors to explore how the human eye works”, the subsequent questions will change, followed by the specific activities used. The same makerspace and supplies can be altered to fit the current defined educational outcomes, while maintaining the roots of a makerspace. Even if the defined educational outcomes never change, different questions and different activities can be alternated to keep the space engaging for returning visitors. The importance lies in creating your defined education outcomes, and to keep them at the forefront of your makerspace design.

Intellectual Scaffolding

Similar to the importance of having defined educational outcomes is intellectual scaffolding. Without intellectual scaffolding, such as prompts, the likelihood that the space will engage and support a large number of visitors is very small. Everyone, regardless of age, intellectual development, or experience, tends to benefit from guidelines, suggestions, and other prompts that serve as reference points during the activity. Intellectual scaffolding is different than instructions because it is not heavily required to complete the task, nor does it directly tell the participant what path to take. An example could be an activity focused on educating visitors on replicating textures in oil paintings. Intellectual scaffolding would provide prompts to suggest possible routes to explore: for example, “how many textures are in this painting?”, “How can you tell the difference between paintings of leather, fur, scales, or cake frosting?”, “How did the artist capture the texture of this product?”, “How would you try to replicate x, y, or z?” and so on. The visitor is free to choose how to explore the activities and can reference these prompts as they see fit. Intellectual scaffolding is also a valuable technique when trying to engage diverse audiences. Varying levels of complexity allow for a wide range of age and experience to participate in the activity. Having simpler questions like, "how do you know this painting is set at night?" match younger audiences. Parents or guardians would be attracted to more complicated questions where they can incorporate their accumulated experience. Intellectual scaffolding does not have to be provided in the form of questions. Prompts with accelerating difficulty is another viable form. A popular example is the "marble run" activity, where different prompts can elicit deeper thinking. The scale of intellectual scaffolding can begin with, "The marble is trying to get from point A to point B", to, "The marble needs to get to point B in 20 seconds without touching anything made out of metal", and, "3 marbles need to switch positions without hitting each other." Visitors do not have to participate in every scenario, but providing scenarios like these can allow visitors to explore in a variety of ways, and to socialize by collaborating, competing, and comparing if they are in a group or family unit. Some visitors may choose to rework a simpler scenario to discover how many different solutions they can create for the same problem, while other visitors may enjoy being given scenarios of increasing difficulty. The variety and optional aspect of intellectual scaffolding is appealing to the largest percentage of visitors, and without them, the task can seem either too simplistic or too overwhelming.

Staff and Training

The ideal number of staff and level of involvement of volunteers will depend on the institution. In general, a makerspace should have one or preferably two or more staff members or volunteers present during all operating hours. When a space is open but unoccupied, it can appear deactivated or uninviting. If a meeting room, cafe, or other social space is advertised as operational but empty upon arrival, it can be confusing for visitors, who may assume the space is currently closed. Other factors can be stronger indicators, like lighting, propped doors, or ambient music, but having people occupy the space can still make a significant difference. From a logistical standpoint, staff and volunteers maintaining a presence in the space has other benefits than creating an active atmosphere. Staff can organize the space, test the activity and create examples of possible outcomes, invite visitors to participate, and answer questions about the space and activity. When there are two or more staff members, the space seems more activated, and they can work together to maintain the space, facilitate engagement, interact with visitors, and collect feedback and evaluations, especially when the space is heavily occupied. The Chabot Space and Science Center staffs its makerspace with a combination of staff and volunteers, both adult and youth. A single staff member and adult volunteers set up the space and test the activity, while alternating shifts comprised of both adult and youth volunteers maintain the space throughout the day. This keeps the space organized, active, and dynamic. Having multigenerational volunteers maintain the space also illustrates to visitors that the activities have the potential to accommodate their own multigenerational group, while providing valuable museum experience for the volunteers.

Training is critical for anyone maintaining a makerspace, due to its specific design that centers around inquiry based and open ended learning. Any staff or volunteers need to understand the approach to visitor learning specific to makerspaces, the defined educational outcomes, how to use intellectual scaffolding, and the importance of inquiry based and open ended learning. It is important that staff and volunteers know how to be a resource without taking over as an instructor or expert. It’s also important to practice ways to facilitate inquiry based and open ended learning, since the lack of a specific outcome can be intimidating for visitors. Staff and volunteers should phrase questions and responses to mimic a participatory dialogue that continues the activity. Questions like, “why did you add this in this way?”, “How did you find that out?”, “what if the scenario changed in this way, how would that affect your product? What could you change and why?” all help the visitor continue to learn and inquire about the possible outcomes they could reach, without suggesting they are better or worse than a different conclusion. The importance of makerspaces lies in the visitors’ journey to their own solution, not a specific outcome alone, so having the skills to encourage and assist visitors would be required. An easy way to begin training is to have staff and volunteers use the space. If an experienced staff member leads them in an activity, it will be a direct way to show the difference in being a resource verses an instructor. Having staff and volunteers form different groups, like families and friends, will allow them to view the space from a different perspective, and understand why certain spaces work better for different groups, and how to invite different groups into the space. An overview of the four key terms would also be essential, and should be delivered in several days of training, including PowerPoint presentations, individual and group activities, hands on activities, time in the space, shadowing a current staff member, and take home assignments, to give staff and volunteers a comprehensive understanding of learning styles and multiple intelligences.

Physical Design of Space

Similar to the points raised about mobile workstations and seating, makerspaces need to have a unique balance of open design with clear designated spaces. The flow of the makerspace will depend on the design of the building, but overall, the goal is to make the space inviting, active, and clear. Spaces that are too secluded can seem closed or exclusive, as well as disconnected or unrelated to the collection or museum as a whole. Open design is the degree to which the space is transparent. This can be accomplished through open doors, large windows, window walls, flow of connectivity to the rest of the museum, or multiple or wide entrances/exits. A space that is physically separated, secluded, with no external visibility (windows and window walls) can seem overtly disinviting or simply closed. If visitors can quickly and easily see into the space without entering, they can get a sense of the purpose and layout without making a commitment to participate, which is less intimidating than walking into a room before knowing what's inside, and whether it is ideal or appropriate for you or your group. If there are doors, they should be propped open during all hours of operation, so it's clear that the space can be entered at any time. Similarly, the space should be well lit, and have some sense of active energy, which can take the form of signage, ambient music, and ideally, as stated above, live staff or volunteers. As discussed in the Dynamic Physical Space section above, certain seating and table designs are better suited for easy rearrangements and to accommodate a wider variety of groups, and should be chosen over stiff, immobile, traditional classroom desks or seating. This furniture helps accentuate the different work stations so workstations are easily identifiable. If a room is fixed in a single group design, like a lecture hall or theatre, it can be intimidating for smaller groups, and restrictive for larger groups, forcing participants to sit side by side instead of in a circle. Alternatively, if there is no organization in terms of designated work stations, the space can seem chaotic, and larger groups may opt out of the activity, assuming it cannot accommodate them, like a crowded restaurant where everyone is eating standing up. Likewise, having a designated location for supplies keeps the space orderly, and allows people to choose what and how much they need, instead of having supplies randomly scattered or chosen for them, potentially limiting or predetermining their exploration of the activity. Several museums with completely different makerspace designs can be used as examples, including the Tinker Tank of the Pacific Science Center in Seattle, the Tech Hive of the Lawrence Hall of Science in Berkeley, CA, the Design Lab of the New York Hall of Science, the Maker Studio of the Denver Art Museum, the MakerSPACE at the Newark Museum in New Jersey, the Maker Lounge at the Peabody Essex Museum in Salem, MA, the Makeshop at the Children's Museum of Pittsburgh, and the CREATE Makerplace at the Arizona Science Center in Phoenix (see Figures 9-15, Appendix B).

Financial Matters

Individual components (building size, duration of project, construction costs, staff costs, etc.) heavily influence the costs of each institution's makerspace, but there are still general expenses that need to be allocated for. These include, but are not limited to, supplies, supply shelving or other types of organization, storage, seating, workstations, signage, software, equipment, and audio/visual capabilities. Costs for staff, training, maintenance, and construction of the physical room will vary greatly for each institution. A sample list of supplies is outlined below. Several potential suppliers are listed below for reference:

Potential Supplies for a Makerspace:

- Ribbon, yarn, string, fabric, tapes, twine
- Legos, building blocks, dominos, marbles
- Paper (wrapping paper, cardstock, construction paper, printer paper, Post-It notes)
- Writing Utensils (pencils, pens, markers, crayons)
- Cardboard (boxes, tubes, sheets)
- Craft Supplies (cotton balls, popsicle sticks, tape, toothpicks, foam, feathers)

- Storage (containers, shelves, labels)
- Sewing tools (fabric, fabric cutter, measuring tape, fabric pens)
- Paint supplies (paint brushes, watercolor paint, canvases)
- Fidget chairs, ball chairs, universal seating, workstations/tables
- Circuitry Kits, Play-Doh
- Polaroid cameras, stop animation recorder, Adobe Acrobat Software, silk screen printer,

<u>Possible Supply Companies:</u>

<u>Supplies:</u> S&S Worldwide, Consumer Crafts, Kole Imports, Fun Express, Paper Mart, Darice, Lakeshore Learning

<u>Storage:</u> Ikea, The Home Depot, Smith System Uline, Discount School Supply, Demco

<u>Furniture:</u> Smith System, Fun and Function, Moving Minds

As the list above implies, makerspaces do not require advanced technology or expensive supplies. Although tools like 3D printers and laser cutters can be impressive and alluring, makerspaces only require thoughtful planning and defined educational outcomes to utilize any supplies to create fun activities that attract visitors and facilitate memorable learning experiences. Several museum makerspaces also successfully utilize their volunteer programs to help manage the space. Yet even with volunteers, a staff member will need to recruit, train, schedule, and supervise them. Another initial fixed cost for a makerspace can be the dynamic furniture.

Funding sources are available specifically to research and establish makerspaces, and many institutions have already taken advantage of them. Since 2012, the Institute for Museum and Library Services has awarded twelve grants to museums for makerspace projects, from the Children's Museum of Pittsburgh to the Fairchild Tropical Botanic Gardens, with awards ranging from $24,975 to $499,211 (see Figure 16, Appendix B)[59]. The National Endowment of the Arts funded a $25,000 grant submitted by the New York Hall of Science related to their Design Lab makerspace in 2017.[60] Also in 2017, the New York Hall of Science, in collaboration with the Amazeum in Bentonville, Arkansas, the Tech Museum of Innovation in San Jose, California, the Creativity Labs at Indiana University and a team of advisors submitted a grant focused on researching the possible connection between narrative elements in makerspaces and gender, and was awarded $1,062,765 by the National Science Foundation.[61] Aside from these museums, other nonprofit organizations, including libraries and public schools, have been awarded grants to research and establish makerspaces for educational purposes. Out of all of the organizations listed, none are classified as art museums. The diversity of institutions on the list, which includes children's museums, historical sites, science centers, aquariums, and botanical gardens, clearly indicate that makerspaces are being implemented in a wide range of environments. Art museums shouldn't assume they are excluded. They too have an opportunity to utilize these resources as other institutions have to pilot makerspace programs and evaluate their potential and effectiveness as an additional tool in their education programming.

How to Evaluate a Makerspace

Since makerspaces are usually free-of-charge to visitors, and do not directly sell goods or services, it would be difficult to evaluate them based on generated revenue. Although possible, it

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[59]IMLS. "Awarded Grants Search." Institute of Museum and Library Services. https://www.imls.gov/grants/awarded-grants?field_project_type=All&field_institution=&field_city=&field_state=All&field_recipient_type=All&search_api_views_fulltext=makerspace&search_api_log_number=&field_fiscal_year_text=&sort_by=field_fiscal_year_text.

[60] NEA. "Awarded Grants Search". National Endowment of the Arts. https://apps.nea.gov/grantsearch/

[61] NSF. "Awards: Understanding How Narrative Elements Can Shape Girls' Engagement in Museum-Based Engineering Design Tasks." https://www.nsf.gov/awardsearch/showAward?AWD_ID=1712803&HistoricalAwards=false.

may also be difficult to evaluate them based on increased visitation, since any increases in visitation during the implementation of a makerspace would need to be linked to the makerspace specifically, although quantitative visitation could be sourced through people counters currently used for galleries in museums being placed at the entrances of the space. Overall, a majority of makerspace feedback and evaluation would be qualitative, which is still useful for analysis and future programming. The goal of evaluations should center on the degree to which the defined education outcomes of the makerspace are translating to visitors, since that is the primary goal of the makerspace. Data and visitor anecdotes can be collected in person by staff and volunteers, or digitally through email, in the form of interviews/focus groups, surveys, and researcher observation. Questions posed in interviews and focus groups are generally open-ended and responses are documented in full, through detailed note-taking or transcription. The purpose of interviews and focus groups is to gather detailed descriptions, from a purposeful sample of stakeholders, of the program processes and the stakeholders' opinions of those processes.[62] Interviews and focus groups can shed light on who uses the makerspace, how, and their response to the activities and outlined educational outcomes. It is important to try to have a diverse group, including age range, museum visitation, and group dynamics, to help evaluate which visitor audiences the makerspace is and is not attracting and why. Observation is an unobtrusive method for gathering information about how the program/initiative operates. Observations can be highly structured, with protocols for recording specific behaviors at specific times, or unstructured, taking a more casual, "look-and-see" approach to understanding the day-to-day operation of the program. Data from observations supplements interviews and surveys in order to complete the

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[62] IMLS"Evaluation Resources." Institute of Museum and Library Services. https://www.imls.gov/research-evaluation/evaluation-resources.

description of the program/initiative and to verify information gathered through other methods.[63] Quantitative data connected to the makerspace can be collected through observation, made by third party researchers, staff, or volunteers. The amount of time visitors spend in the space, the number of visitors, and other numerical data can be collected without interrupting the activities. This data is important, because it help support the makerspace as a resource while informing staff about potential aspects, like number of seats or average time spent at each station, which can be used to improve the space. Surveys and questionnaires are also conducted with evaluation and program/initiative stakeholders. The purpose of surveys/questionnaires is to gather specific information—often regarding opinions or levels of satisfaction, in addition to demographic information—from a large, representative sample.[64] This data can be used to determine the makerspaces effectiveness in reaching more diverse audiences, and their interpretation of the activities and inquiry based/open ended programming. If visible recurring patterns or issues can be highlighted through survey data, then there is a greater chance of isolating and improving them. Regardless of which evaluation types are used, overarching requirements of data collection are that a large and diverse pool of applicants are used, meaning different ages, genders, groupings, languages, and physical and mental abilities. If the data collected is extensive, but only representative of a single type of applicant (English speaker, parent, active museum member), the information's usefulness is minimal. Another critical point is to collect data from the beginning of the creation of the makerspace, with regular evaluations of the information throughout the makerspace operation. This is important, because the sooner an issue is discovered, the sooner it can be addressed. For instance, a makerspace might not seem popular due to low visitation, but the specific reason for the low visitation can vary, including issues with

[63] Ibid.
[64] Ibid.

approachability (doors propped open, signage, lighting), comfortability (seating, space), organization (supply maintenance, clarity of signage/stations), or advertisement of the space. By implementing a cyclical evaluation process, the makerspace can improve in real time, and be customized to best fit that particular museum's visitor community.

Conclusion

Why should art museums change how they educate? Why are multiple intelligences and makerspaces important? The answer lies in who is left out when we don't consider the multiple ways in which people learn. We have all had experiences where a random school subject, sport, language, or instrument felt impossible to learn, despite the fact that we excel in other academic and leisurely activities. That does not mean we, or anyone struggling to learn a new skill or concept, should be labeled "stupid", or a "hopeless case". Everyone learns in highly complex, multisensory ways that fluctuate depending on the task. The better this is understood and implemented in learning environments, the better chance more people have at succeeding, learning, growing, and becoming more confident in themselves. The oversimplification of categorizing people into "smart" or "dumb" severely limits everyone's potential. As our understanding of the physiology of human learning, social learning dynamics, and multiple intelligences increases, so too must our educational ability to respond to them. If we understand people have greater abilities to learn when given the same information in a wide variety of ways, it seems only logical to begin to design ways for diverse information presentation to occur: hence, a makerspace. Through my literature review, I have connected major Progressive Education theories to the design and implementation of makerspaces. In my proposal, I have outlined key terms for successful visitor learning and recommendations for implementing a makerspace in museums, especially art museums. Other types of museums, as well as community centers, libraries, and schools, have all began to explore and benefit from adding makerspaces to their education programming. Shouldn't art museums?

Several influential concepts were outside the scope of this project, but should be researched in combination with makerspaces for future study. These include the history and evidence of the success of Montessori schools, developed by Dr. Maria Montessori as well as other kinds of progressive schools, the history and relationship of makerspaces in libraries, and the importance and implementation of design thinking within makerspaces. Further research should also include data collected through observational and evaluation data from a wide variety of museum makerspaces for comparison.

The American Alliance of Museums states that, “there are approximately 850 million visits each year to American museums, more than the attendance for all major league sporting events and theme parks combined (483 million in 2011).”[65] Additionally, “museums are considered educational by 98% of Americans, across all ages, races, and geographical locations.”[66] People love museums and want to learn in them, which creates a demand and expectation that museums provide opportunities for learning to occur. With the help of makerspaces, art museums, and all public serving institutions, can continue to grow. As George Hein explains, “because our genes and our experiences are unique and because our brains must figure out meanings, no two selves, no two consciousnesses, no two minds are exactly alike. Each of us is therefore situated to make a different, unique contribution to the world. In the recognition of our individuality, we may discover our deepest common tie - that we are all joint products of natural and cultural evolution. And we may discover why we must join forces, in a complementary but synergistic way, to make sure that nature and culture survive for future generations.”[67] Makerspaces are important educational tools that prioritize and foster discovery. This is why they are important educational tools not just for science or children’s museums. They are also educational tools for art museums, because they are educational tools for everyone.

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[65] AAM. "Museum Facts & Data." American Alliance of Museums. https://www.aam-us.org/programs/about-museums/museum-facts-data/#_ednref22.
[66] Ibid.
[67] Hein, *Intelligence Reframed,* 218.

Appendix A: Annotated Bibliography

1. Dewey, John. Art as Experience. New York: Capricorn Books, 1958.

This book details John Dewey's ideas around the concept of art as experience and its connection to nature. It is written by Dewey himself, so while the language is slightly dated, it is a primary resource in terms of his teachings and educational philosophy. It breaks down how art is deeply connected to life and the everyday, its importance to the public, as well as art as a way for humans to communicate to one another beyond language. This book is one of the major pillars upon which my argument is built, since he is one of the founders of the progressive education movement, and many of the later and present educators and philosophers I'm researching are rooted in his teachings.

2. Gardner, Howard. Intelligence Reframed: Multiple Intelligences for the 21st Century. New York: Basic Books, 1999.

Howard Gardner is another major original educator, and his theories are the catalyst for many studies and scientific experiences that all support my argument for the value of diverse methods of learning. This book, written by Gardner, compares the ideas surrounding education and learning before his multiple intelligences theory, and how his ideas are different, radical, yet valid and grounded in evidence. It not only explains his interpretation of the individual and how we retain experiences, but it also clarifies the myths and misconceptions around his theories, which will be very helpful. Understanding this theory clearly is critical to my argument, because it is the theory that leads to the modern day science which supports it. It is crucial that I do not misinterpret or misunderstand his teachings, which is why I'd prefer his own words rather than someone's later interpretation alone.

3. Hein, George E., and Mary Alexander. Museums: Places of Learning. Washington, DC: American Association of Museums, Education Committee, 1998.

This book is a helpful play by play of the current successes and failures of the educational potential of a museum space. It explains, through studies and observations, how children and adults tend to navigate museum spaces, how comfort is the key to participation, how visitors stay longer if there are interactive components, and how these observations relate back to the Educational Theory chart and the teachings of John Dewey, Jean Piaget, and others. This book is an ideal conglomerate of studies and statistics that I can pull to support my specific argument, as well as an efficient handbook on the do's and don'ts of museum education. Understanding what makes and breaks an interactive museum space will help me tailor my own chart on ideal characteristics and argue why a makerspace specifically emulates the positive aspects discussed in this book.

4. Hein, George E. Learning in the Museum. Abingdon, UK: Routledge, 1998.

This is another book by George Hein that breaks down learning in the museum in great detail. It points out that as an object based institution, museums are built for “discovery learning”, which is a specific concept within constructivism. Unlike the book above, this is Hein’s philosophical and logical breakdown of how learning occurs, and how concepts become extensions of our world when we experience them, explaining how important direct, personal experience with objects are to long term learning. He also explains how and why audiences have different levels of intellectual development, connecting back to the multiple intelligences theory and the importance of catering to a diverse group of people as opposed to honing in on a single popular form of learning. It is helpful to me to have both Hein’s overall philosophical teachings as well as his black and white breakdown of a physical museum space, to see how they are connected. I am attempting to do the same thing in a different context, so seeing these examples helps as a reference and guide.

5. Hein, George E. Progressive Museum Practice: John Dewey and Democracy. Walnut Creek, CA: Left Coast, 2012.

This book is highly useful to me because it is a timeline and connection between the several different focal points of my literature review. This books outlines the steps taken from traditional education theories, John Dewey, the progressive movement, and where museums currently stand on the issues in the 221st century. This book essentially serves as an outline for my literature review (aside from the scientific component) and keeps my paper on track. It helps me to not only stress the most important plot points, but helps me from deviating too far off the overall narrative. It’s also helpful to have a modern day take of the movement to compliment the original writings of the educators discussed, and bring them into the present day, since my proposal helps to further the conversation into the future designs of museum spaces.

6. Kroski, Ellyssa. The Makerspace Librarian's Sourcebook. Chicago: ALA Editions, an Imprint of the American Library Association, 2017.
It breaks down how to design a makerspace, how to budget for one, how to prototype your lesson plans, and how to plan for sustainability in terms of a permanent space, not a fad. It uses actual examples of makerspaces in libraries to show how different goals will require very different makerspaces, and why those differences are so important. Just as with the educational theories, I need a balance of the philosophy and arguments behind the idea of a makerspace, as well as the tangible, viable planning of one. If I don’t have a good understanding of both, my overall argument will either be too theoretical or not grounded in evidence.

7. Kuhlthau, Carol C., Leslie K. Maniotes, and Ann K. Caspari. Guided Inquiry: Learning in the 21st Century. Westport, Connecticut: Libraries Unlimited, 2015.
This book is a more scientific take on the educational theories I’m researching. It reviews what “inquiry learning” is, the interplay of thinking, feeling and acting, how learning environments increase brain waves, and how the “ISP” model works. ISP stand for Information Search

Process, and begins with our initial feeling, thoughts, and actions when faced with an unfamiliar concept, and traces human behavior through several steps to finally arrive at assessment. It also wrestles with the potential issues of "guided inquiry" and uses real world examples for best practices and failures. The ISP model is a recurring theme in my research, so having a detailed breakdown of the design and evidence behind it is essential. It's always also very important to recognize the issues and current shortcomings of new ideas in order to face and improve them, so having them already listed helps me synthesize my argument and prepare for skepticism.

8. Lillard, Angeline Stoll. Montessori: The Science behind the Genius. New York: Oxford University Press, 2017.
The Montessori school system is closely related to my topic and overall argument because it was a physical manifestation of the educational theories previously discussed, yielding huge records of data and evidence of success of the progressive education movement and a diversifying of learning pathways. This book is especially useful because it focuses on the science behind why the Montessori school system works, linking back to the theories and science I'm using to defend my own argument. Is a way, the Montessori school is a hybrid between a traditional school program and a makerspace, and with a long history of programs across America, it will be a good source of supportive hard data. This book focuses on the impact of movement on learning and cognition, meaningful contexts for learning, how order in the environment affects order in the mind, and concludes with recent research on Montessori education, helping me bring my argument to the present day.

9. Little, Tom, Katherine Ellison, and Ayelet Waldman. Loving Learning: How Progressive Education Can Save America's Schools. New York: W.W. Norton & Company, 2015.
This is a present day overview of the progressive education movement and its connection to current education in schools. This book contains important ideas pertaining to my argument, including the concept of "teaching the 'whole' child", learning through activating the senses, and how important it is in child development to have a 'laboratory' space where they can openly experiment, rapid prototype, and learn how they want at their own pace without a highly specified destination. It also ties back into the strengths and vulnerability behind the progressive education movement, and how to move forward. The ideas behind a laboratory space are the same as those defending the makerspace, so this book is a good example of others making similar arguments, which will help me articulate mine.

10. Martinez, Sylvia Libow, and Gary Stager. Invent to Learn: Making, Tinkering, and Engineering in the Classroom. Torrance: Constructing Modern Knowledge Press, 2013.
This book is a good backbone for the section of my literature review that focuses on makerspaces. It outlines the history and development of makerspaces, how they came from tinkering and hackerspaces, what makes them different, the learning behind them, and how they relate to STEM and STEAM. It is very important to me to use this capstone to bridge the artistic

and scientific fields and show how the makerspace is a successful mixing of the two, so emphasizing how makerspaces help elevate the Art in STEAM is important. This book also has a chapter that is devoted to arguing in favor of makerspaces in public institutions, which will be incredibly helpful as a reference since I'm arguing in favor of them in museums.

11. Peppler, Kylie A., Erica R. Halverson, and Yasmin B. Kafai. Makeology: Makerspaces as Learning Environments. New York: Routledge, 2016.
This book is going to be the pillar of my makerspace section. It is the overall guide that many of the more specific books stem from. It has key concepts not usually covered in makerspace books or articles, particularly how museum educators and designers need to seriously consider the parents and not only the kids, since the parents control what their kids interact with and how long. Taking them into consideration in terms of space and participation is essential to an inviting and engaging makerspace. Since I want my makerspace characteristics to reflect a more universal space for a wide variety of users, and not solely young children, these arguments will be integral to my own. It also reviews makerspaces in museums, and how learning needs to be designed as a trajectory of participation through museum educators facilitating designed experiences. A large majority of makerspaces prioritize children or teens, so this book is unique in its emphasis on adult participation, even including chapters on adult makerspaces. It will be helpful to pull key points from these different audiences to develop a method for design that tries to adhere to most visitors to some degree.

12. Sheninger, Eric C. Uncommon Learning: Creating Schools That Work for Kids. Thousand Oaks, CA: Corwin, 2016.
This book helps bridge and define artistic and educational concepts. It breaks down how the creative process is parallel to deep learning, and explains "open ended learning" in great detail, which is the crux of makerspaces. It also articulates how when students learn in this way, they value the experience and the knowledge gained much greater than through traditional methods, because they discovered ideas and tested concepts by themselves instead of being told what and how to think. This book is also like a brass tax for makerspace creation because it has key implementation tips and goes over the potential for makerspaces in present day institutions.

13. Simon, Nina. The Participatory Museum. Santa Cruz, California: Museum 2.0, 2010.
This book is the cornerstone of my argument related to museums as diverse public spaces and their metamorphosis into engaging, open institutions of learning and socializing. Nina Simon uses statistics and studies to outline the different types of participants a museum will face, and what percentage of visitors make up these groups. She then reviews the concept of self-directed creativity and instructional scaffolding to maximize and diversify visitor participation. She also discusses the Denver Art Museum, which is one of the museums from the AAM conference I plan on analyzing in my characteristics chart. This book helps me streamline my thought process and argument, and helps me keep museums at the forefront of my discussion. Makerspaces and

education can very easily delve into schools and libraries, so it's important to use books like this to continuously bring it back to the museum field specifically.

14. Steffe, Leslie P., and Jerry Edward. Gale. Constructivism in Education. New York: Routledge, 2009.
This book serves as a primary source of the major concepts of the constructivist movement, namely, construction and transference of meaning through form, sensory experience, and abstraction. Constructivism is all about problem solving and learning through direct experience, and is the organized theory that serves as a major part the foundation for the Montessori school system and makerspaces. This book is unique in that it heavily emphasizes the senses and their involvement in learning, which is the connection between the theoretical and scientific pillars of my argument. The science behind diverse pathways of learning is the result of how the senses work, how they're connected to the central nervous system, and how they send information to the brain, in addition to how that information is stored. It is difficult to find writing that connects theoretical constructivism to human physiology, so this book will be a critical reference when that portion of my argument ties in.

15. Willingham, Theresa, and Jeroen De. Boer. Makerspaces in Libraries. Lanham: Rowman & Littlefield, 2015.
This book is helpful for two reasons: it begins with the major concerns and considerations when contemplating the implementation of a makerspace in an institution, and it has a vast collection of examples of current makerspaces. This will be most useful when formulating my characteristics chart, because I can see what reoccurring conceptual ideas repeat through these many different iterations of a makerspace. I can also see patterns of failure which I can comment on and avoid. This book is also a key connecter of education, art, and science, because it ties makerspaces to fostering creativity and invention, which are usually concepts involved in education programs in art museums. Part of my overall argument has to answer what makerspaces specifically can add to the already hefty portfolio of the art museum education department, so this book will help articulate that argument and provide examples as support.

Appendix B: List of Figures

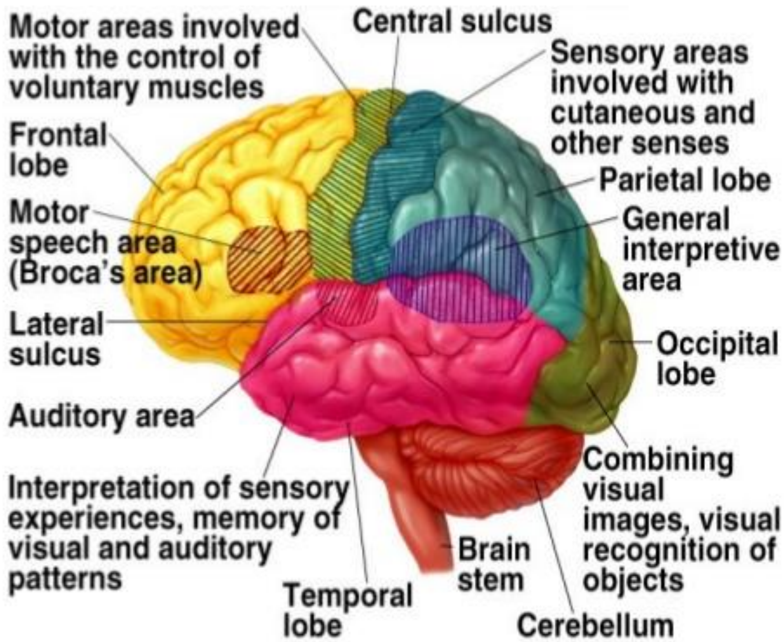

Figure 1. The Central Nervous System: Physical Locations of Sensory Information in the Brain. Chy Yong, Medical Doctor Follow. "The central nervous system." LinkedIn SlideShare. October 07, 2015. https://www.slideshare.net/Yon360/the-central-nervous-system-53628355.

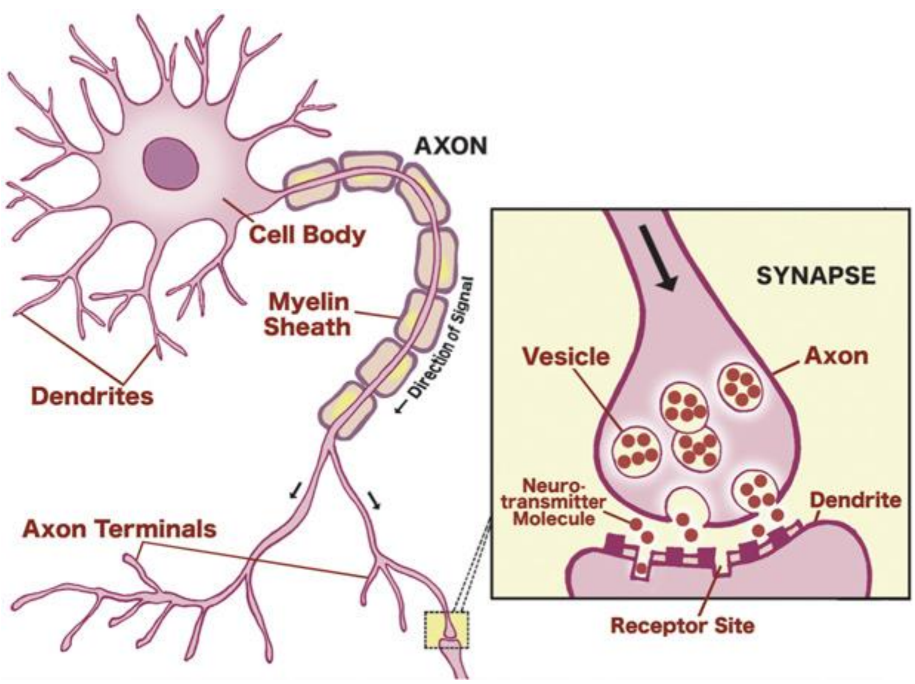

Figure 2. Illustration of neuron and synapse. "Baby's Brain Begins Now: Conception to Age 3." The Urban Child Institute. http://www.urbanchildinstitute.org/why-0-3/baby-and-brain.

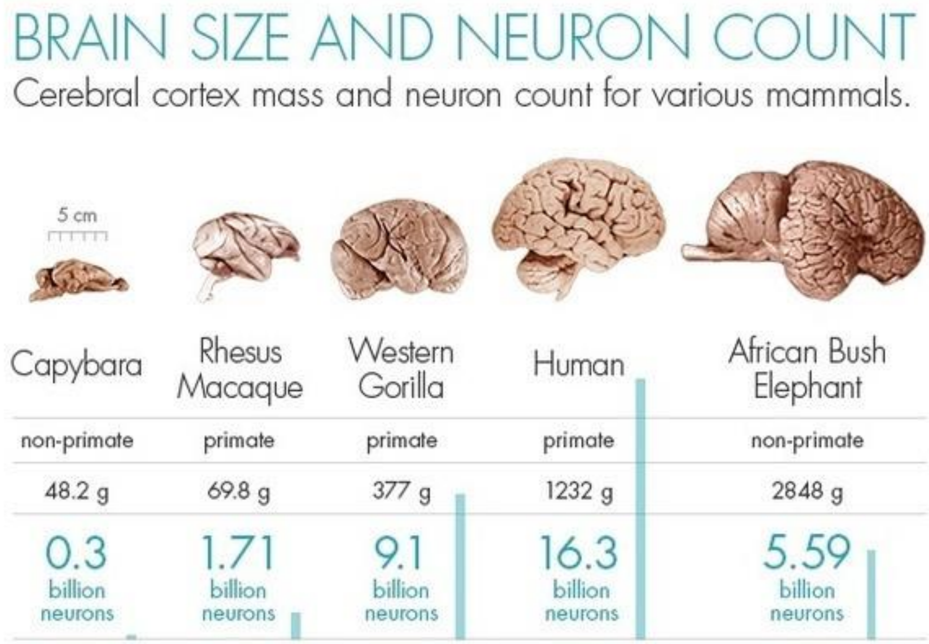

Figure 3. Cerebral cortex mass and neuron count for various mammals. “Why do Larger Animals Typically Have Larger Brains?” Quora. https://www.quora.com/Why-do-larger-animals-typically-have-larger-brains.

Figure 4. Examples of visitor made bugs from Chabot Space and Science Center makerspace activity from 2017 Bay Area Science Festival at AT&T Park in San Francisco. Photo credit Kaeleigh Thorp.

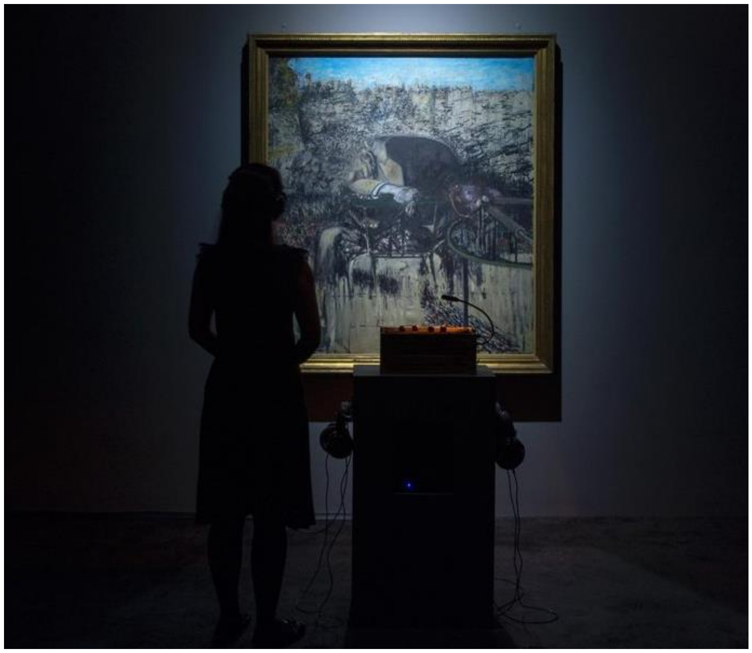

Figure 5. Visitor engaging with Francis Bacon’s *Figure in a Landscape*, *Tate Sensorium* Exhibition, Tate Britain Museum. Tate. "IK Prize 2015: Tate Sensorium." Tate. 2015. http://www.tate.org.uk/whats-on/tate-britain/display/ik-prize-2015-tate-sensorium.

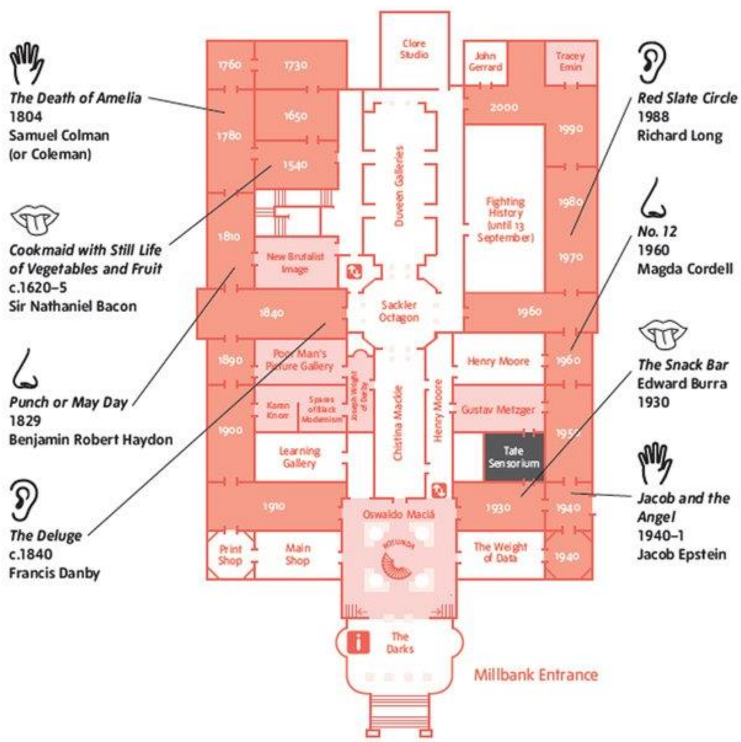

Figure 6. Layout of *Tate Sensorium* Exhibition, Tate Britain Museum. "IK Prize 2015: Tate Sensorium." Tate. 2015. http://www.tate.org.uk/whats-on/tate-britain/display/ik-prize-2015-tate-sensorium.

Figure 7. Examples of visitor made spaceships as part of Chabot Space and Science Center Makerspace Project Create Activity. Photo Credit Kaeleigh Thorp.

Figure 8. Examples of Smith System mobile and multi-group seating and furniture. "Student Desks." January 04, 2017. https://smithsystem.com/student/.

Figure 9. Tinker Tank makerspace at the Pacific Science Center in Seattle, Washington. Totey, Jeffrey. “Tis the Season for Science at Pacific Science Center.” November 19, 2017. http://redtri.com/seattle/family-guide-to-the-pacific-science-center/.

Figure 10. The Tech Hive at the Lawrence Hall of Science in Berkeley, California, during the 2016 2nd Annual Robot Petting Zoo Makeathon. "2nd Annual Robot Petting Zoo Makeathon." TechHive. http://www.techhivestudio.org/projects/2016/5/29/2nd-annual-robot-petting-zoo-makeathon.

Figure 11. The Design Lab of the New York Hall of Science in Corona, New York. "Design Lab – NYSCI." NYSCI. https://nysci.org/make/designlab/.

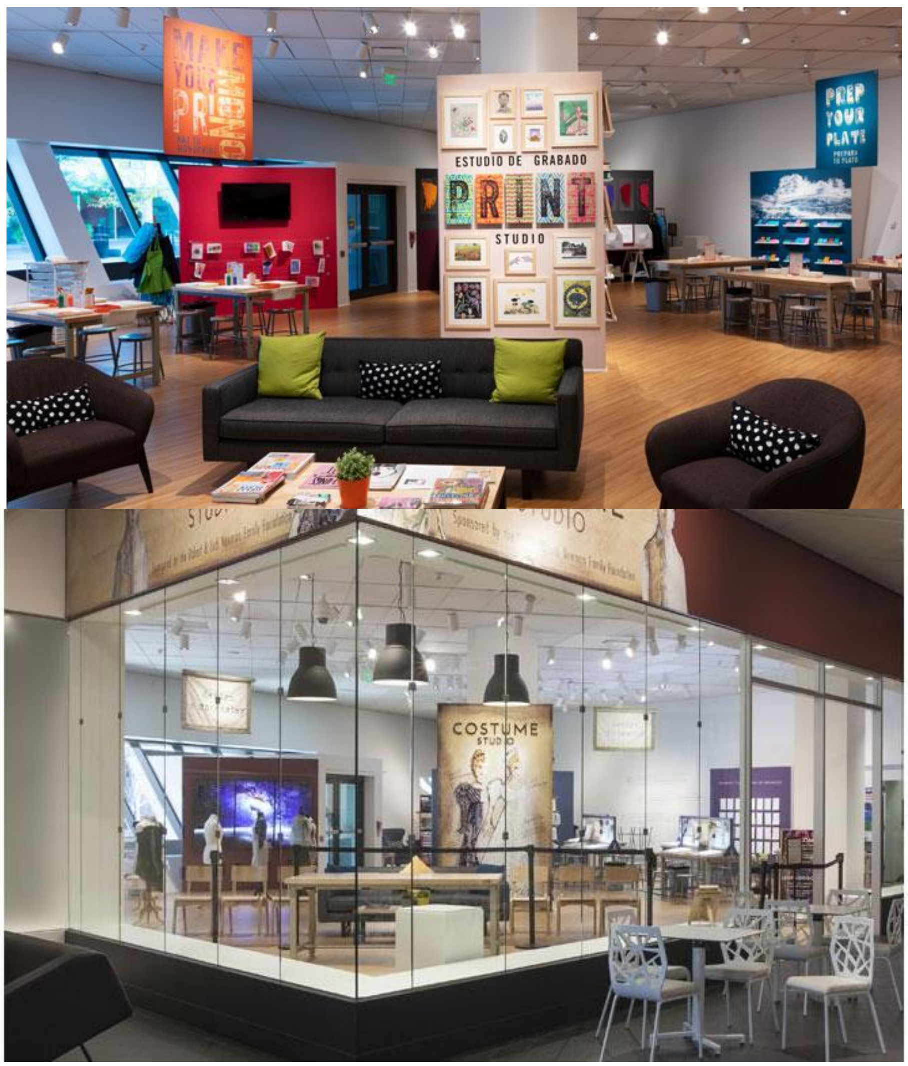

Figure 12. The maker studio in the Denver Art Museum in Denver, Colorado as a print studio and costume studio. "Print Studio." Denver Art Museum.

https://denverartmuseum.org/programs/studio. Brice, Carleen. "Costume Studio Artist Profiles." Denver Art Museum. https://denverartmuseum.org/article/costume-studio-artist-profiles.

Figure 13. The Maker Lounge at the Peabody Essex Museum in Salem, Massachusetts. "Playing with Art and Nature at the Peabody Essex Museum, Salem, Mass." Playscapes. http://www.play-scapes.com/correspondent_post/playing-with-art-and-nature-at-the-peabody-essex-museum-salem-mass/.

Figure 14. The Makeshop at the Children's Museum of Pittsburgh. "In the MAKESHOP - Informal Learning and Making at the Children's Museum of Pittsburgh | Make:." Make: DIY

Projects and Ideas for Makers. https://makezine.com/2012/08/30/in-the-makeshop-informal-learning-and-making-at-the-childrens-museum-of-pittsburgh/.

Figure 15. The CREATE Makerplace at the Arizona Science Center. "Makerspace in Preschool- It's Not Just for Big Kids!" Medium.com. February 27, 2018. https://medium.com/@marissacalderon/makerspace-in-preschool-its-not-just-for-big-kids-67ce0dad016e.

Recipient Name	Award	Fiscal Year
Pacific Science Center	$85,787.00	2018
Fairchild Tropical Botanic Garden	$247,690.00	2018
Peoria Playhouse Children's Museum	$87,567.00	2017
Children's Museum of Pittsburgh	$150,000.00	2016
Children's Museum of Pittsburgh	$499,211.00	2016
Children's Museum of Winston-Salem	$146,852.00	2015
Hands On Children's Museum	$148,488.00	2015
San Antonio Children's Museum	$144,922.00	2015
ECHO Lake Aquarium and Science Center	$142,891.00	2015
The Children's Museum	$24,975.00	2015
Children's Museum of Pittsburgh	$149,611.00	2014
Children's Museum of Pittsburgh	$444,296.00	2012

Figure 16. List of museums awarded makerspace related grants through the Institute for Museum and Library Services from 2012-2018. Chart credit Kaeleigh Thorp.

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