Fall 12-15-2014

# Integrating the Arts and Sciences in the Museum Setting

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Submitted in partial fulfillment of the requirement for the degree

Masters of Arts in Museum Professions

College of Arts and Sciences

Seton Hall University

December 2014

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## Abstract

The division between the arts and sciences appears to be deepening in America. As political leaders emphasize STEM (science, technology, engineering and math) education in schools, arts education is diminished to make room for STEM courses. Concerned about this phenomenon, many art educators are working to integrate the arts into STEM education through a variety of arts integration efforts. Arts integration not only helps to preserve a place for the arts in the curriculum, it also has been shown to enhance STEM learning.

Arts integration is of special interest to art museum educators who feel that they can provide resources to help teachers integrate the arts into STEM. By offering arts integration curricula, a museum supports its community and maintains its own relevance. Also, while general museum funding is decreasing, grant money is being made available to museums to support the areas of STEM and arts integration. Schools are also more inclined to visit museums when the museum can provide arts integration that ties to STEM learning.

This paper explores five efforts by museums to support their communities and retain their relevance through arts integration programs. The case studies include the J. Paul Getty Museum in Los Angeles, California; The National Museum of Math in Manhattan, New York; The Walters Art Museum in Baltimore Maryland; The Kennedy Center ArtsEdge in Washington D.C., and the Museum of Glass in Tacoma, Washington. These case studies review the development of the arts integration programs at each museum, describe the programming and review lessons plans, and demonstrate how they benefit students and teachers. Evaluations and critiques of each program are included.


**Keywords**: Arts Integration, STEM Education, STEAM Education

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INTEGRATING THE ARTS AND SCIENCES IN THE MUSEUM SETTING

## Introduction

Leonardo Da Vinci created works of art that have inspired generations – but he also made blueprints for an airplane-like device and captured human anatomy in incredibly detailed drawings. Da Vinci observed the world around him and recorded these observations in his journals in the form of sketches. His journals included countless studies of the individual parts of a flower and anatomical studies of humans and animals. He used these studies to inform his paintings and to make extremely life-like renderings of his subject, thereby using his scientific observations and knowledge to inform his art. His work serves as one of the most magnificent examples of art and science integration. Unfortunately, over the years the arts and sciences have become disconnected. This is particularly true for the field of education, in which they are often viewed as competing disciplines in the struggle for both education hours and funding.

The division between the arts and sciences is deepened as political leaders emphasize science education. The National Science Foundation funds over five billion dollars to programs and initiatives for science education while the arts and humanities only receive about 250 million dollars a year.[1] This focus on the sciences has taken the name of STEM education. This stands for science, technology, engineering and math. The emphasis on STEM comes at the cost of other disciplines, notably the arts, which is seen as a problem by many art educators (visual arts, dance, music, etc.) who feel that their disciplines will eventually be taken out of school curriculum. Given these concerns, many art educators are

[1] "11 Facts About Arts in Education," DoSomething.org, February 2014 accessed September 24, 2014. https://www.dosomething.org/facts/11-facts-about-arts-education

working to integrate arts into STEM education through a variety of arts integration efforts. They argue that by focusing on STEM education, students are not acquiring vital skills that can be developed by the arts, such as creativity, collaboration, and critical thinking.

To overcome this problem, two separate though related strategies have been developed. One is the integration of the arts into STEM disciplines allowing these subjects to be taught alongside each other. This is the primary method that will be discussed in this paper. The other is STEAM (STEM plus an A for Arts). STEAM is a specific type of arts integration within a specific framework. STEAM was developed using principles of Inquiry Based Learning - a combination of problem solving, hands-on-projects, and design-based learning.[2] By thinking about what they are doing along the way and at the end of the process, students get a chance to learn the material in depth.[3] Educators sense that teaching the arts and sciences together would allow children to develop the skills necessary for life in the modern day.

This paper showcases the role played by museums in the area of arts integration in primary and secondary education. In the remainder of this section, I intend to expand on the history and nature of STEM education to better show what is driving the current interest in and need for arts integration programs. After discussing arts integration programs in schools and their effectiveness, I will demonstrate the important role museums play in the area of arts integration in STEM education. The bulk of the thesis will consist of an in-depth discussion of five museum programs currently available to educators

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[2] Neil Stephenson, "What is 'inquiry-based learning'?," Thinking in Mind, accessed November 6, 2014, http://www.thinkinginmind.com/2011/08/what-is-inquiry-based-learning/

[3] Georgette Yakman "STEAM - Learning That is Representative of the Whole World" (video of Lecture, Big Ideas Fest 2011, Half Moon Bay, Ca, February 9, 2012), accessed November 6, 2012, http://www.youtube.com/watch?v=QtjuALN4qrw

looking for ways to integrate the arts and sciences**.** These case studies include the J. Paul Getty Museum in Los Angeles, California; The National Museum of Math in Manhattan, New York; The Kennedy Center *ArtsEdge* in Washington D.C.; The Walters Art Museum in Baltimore, Maryland and the Museum of Glass in Tacoma, Washington.

# Chapter 1

## Arts integration in Schools

To understand the importance of arts integration, it is important to know about STEM, the driving factor in education in the United States today. STEM stands for Science, Technology, Engineering and Math. Judith Ramaley, former director of the National Science Foundation (NSF) Education and Human Resources Division, coined the term STEM in 2001.[4] Ramaley believed that,

> Science and math are critical to a basic understanding of the universe, while engineering and technology are means for people to interact with the universe. STEM weaves those elements of human action and understanding into all aspects of education.[5]

The NSF and Ramaley saw that the United States was falling behind the rest of the world in the STEM fields and realized that something needed to be done to change this. The concept of STEM was not merely to focus on the individual subjects of Science, Technology, Engineering and Math but rather to integrate these four disciplines by showing the real world application of these disciplines.[6]

STEM education was propelled into the national spotlight in 2009 when President Barack Obama called for the United States to increase its role in the global world of science and technology. In a widely publicized speech introducing his "Educate to Innovate" campaign, he said, "Leadership tomorrow depends on how we educate our students today,

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[4] Jerome Christenson, "Ramaley coined STEM term now used nationwide," Winona Daily News, November 12, 2011, accessed October 10, 2014.
[5] Ibid.
[6] Elaine Hom, "What is STEM Education?" Live Science, February 11, 2014 accessed October 10, 2014. http://www.livescience.com/43296-what-is-stem-education.html

especially in those fields that hold the promise of producing future innovations and innovators. And that's why education in math and science is so important."[7] President Obama and his staff want to move America forward in the competition with other nations. The United States is only ranked 25th in math and 17th in science compared to other industrialized nations.[8] The President is also pushing STEM education because of the growing need for employees to fill STEM related positions; there will be an expected 8.65 million STEM related jobs in the United States in 2018.[9] The US Department of Education projects a sixty-two percent increase in biomedical engineering jobs and a thirty-two percent increase in system software developer positions from the years 2010 to 2020. There is an expected fourteen percent increase in all occupations in the United States during this time.[10] However, statistics show that students do not feel prepared for college in these fields. Research was conducted and the NSF found that one in five college students majoring in the STEM fields did not feel prepared for their STEM related classes when they entered college.[11] A survey by the Department of Education showed that only sixteen percent of high school graduates were proficient in math and interested in a STEM related career.[12] President Obama has challenged the colleges and universities of the United States to graduate an additional one million students in the STEM majors by 2020. To do this, the "Educate to Innovate" campaign is focusing on women, Hispanics, African Americans, and

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[7] Barak Obama, President of the United States, "Remarks by the President on the 'Education to Innovate Campaign'" (Speech, South Court Auditorium, Dwight D. Eisenhower Executive Office Building, Washington D.C, November 23, 2009)

[8] "Science, Technology, Engineering and Math: Education for Global Leadership," U.S. Department of Education, accessed October 10, 2014. http://www.ed.gov/stem

[9] Hom, "What is STEM Education?"

[10] "Science, Technology, Engineering and Math: Education for Global Leadership"

[11] "STEM Perceptions: Student and Parent Survey," STEM Education Coalition, accessed on November 7, 2014. http://www.stemedcoalition.org/wp-content/uploads/2013/10/STEM_Perception_Report.pptx

[12] "Science, Technology, Engineering and Math: Education for Global Leadership"

people with disabilities, population groups that are currently underrepresented in STEM related jobs.[13]

While politicians are pushing for more STEM education in the schools, there are people who are concerned about the single-minded focus on math and science. Many educators, especially those in art disciplines, feel that STEM is placing the arts in opposition to the sciences. As arts are being pushed out of the schools, many in the education field believe that there needs to be a pushback, one that is similar to the push for STEM education that involves the arts.

Arts integration - the idea that the arts can be integrated with other disciplines to create a better, more memorable learning experience is not a new idea. For example, generations of American school children have learned the Alphabet to the tune of "Twinkle, Twinkle Little Star". This author was taught the quadratic equation through the music of "Pop Goes the Weasel" (and remembers it to this day). However, in recent years, this idea has become more important as STEM education holds both the political and funding advantages as was discussed above. Educators recognize that the emphasis on STEM at the expense of the arts, leaves students without important life skills, such as creativity, collaboration, and critical thinking. Arts integrations can help fill this gap. For example, a study done by the National Assembly of State Arts Agencies (NASAA) shows that beyond the academic benefits seen by arts learners in the areas of reading, language and mathematics, students also gain improved skills in critical thinking, collaborating, socializing and an enhanced motivation to learn when art is part of the lesson plan.[14]

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[13] "Science, Technology, Engineering and Math: Education for Global Leadership"

[14] Sandra Ruppert, "Critical Evidence: How the Arts benefit Student Achievement," *J. Paul Getty Museum*, (2006) December 5, 2014, http://www.nasaa-arts.org/Publications/critical-evidence.pdf Pg. 10

Other studies report both similar and further benefits to arts integration. For instance, a 2012 study done at Lesley University in Cambridge, Massachusetts noted that arts integration leads to increased academic achievement and student retention, as well as increasing teacher performance. This study found that arts integration leads students to a deeper understanding of the material taught and stronger student engagement. It also noted that arts integration provided more strategies for students to express understanding of materials and for teachers to make the learning more relevant to the student.[15] For instance, students at Normal Park Museum Magnet School in Chattanooga, TN are challenged to create their own textbooks to show their understanding of the materials. They create journals that "include writing and reflection pieces, graphic organizers, timelines, charts, drawings, diagrams, vocabulary, maps, pictures, and anything else that reflects students' learning and understanding of the module topic."[16] The study also noted that arts integration helped students gain skills in critical thinking, creativity, collaboration and understanding of multiple perspectives which the study's authors related as skills desired by today's businesses. Finally, the study noted that arts integration allowed students to "develop empathy, awareness of multiple perspectives and cultural sensitivity to others.[17]

This study also found that teachers benefited from professional development in arts integration. This development gives teachers valuable experience and practice in teaching a more dynamic and creative process model. Other positives noted were an increased ability

[15] K. Bellisario, and L. Donovan, "Voices from the field: Teachers' views on the relevance of arts integration," ArtsEdge, accessed November 6, 2014 Cambridge, MA: Lesley University. http://www.artsedsearch.org/summaries/voices-from-the-field-teachers%E2%80%99-views-on-the-relevance-of-arts-integration

[16] "Travel Journals: Student-Created Text Books," Edutopia, August 14, 2014 accessed November 14, 2014, http://www.edutopia.org/practice/creating-travel-journals-assess-learning

[17] K. Bellisario, and L. Donovan, "Voices from the field"

to differentiate their teaching to meet many types of learning styles and to meet a broader range of cultural perspectives. The study noted that teachers involved in arts integration reported a renewed commitment to teaching.[18] This renewed commitment will create teachers who are actually enjoying their work and who feel fulfilled. This will trickle down to their students; students will see their teachers having fun, which will translate to the kids having fun.

To achieve the best results from arts integration, several conditions must be met. Sue Riley, an Arts integration Specialist notes that arts integration is not a simple process. She writes that arts integration is not just combining two disciplines but rather it is a teaching approach that aims to improve the level of learning for both disciplines.[19] Riley says,

> Integration requires collaboration, research, intentional alignment and practical application on behalf of the teachers who take on this challenge. From the students, integration demands creativity, problem-solving, perseverance, collaboration and the ability to work through the rigorous demands of multiple ideas and concepts woven together to create a final product.[20]

She notes four main benefits of arts integration: a curriculum aligned to students' real lives, a teaching approach suited to reach out to various types of learners,

[18] K. Bellisario, and L. Donovan, "Voices from the field"
[19] Susan Riley, "Use Arts Integration to Enhance Common Core," Edutopia, November 30, 2012 accessed November 7, 2014. http://www.edutopia.org/blog/core-practices-arts-integration-susan-riley
[20] Ibid.

opportunities for students to practice analytical learning, and an opportunity for students to focus on process rather than product.[21]

While the climate of education in the U.S. today seems to favor STEM, arts integration is widely seen as an important strategy to enhance STEM learning while also teaching the arts. As was discussed above in the review of the studies by NASAA and by Lesley University, positive learning outcomes support this concept. Integrating the arts into science education will allow students to have a more thorough understanding of the world. Lawrence Weschler, a noted writer and professor of the Humanities and an advocate for arts integration writes,

> One of the things I've long been interested in is the notion of returning to a time when the sciences were at the heart of the humanities, when there was a marvelous, polymorphous, promiscuous interaction between scientists, artists, wizards and inventors. The division between arts and sciences is only 300 years old at most. Before that, people like Michelangelo and Leonardo were as much scientists as artists. There was no distinction between the different interests they were pursuing.[22]

Can arts integration help create a generation of DaVincis? That is probably a long shot, but it can help prepare students to think more critically and to excel in both the arts and sciences.

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[21] Riley, "Use Arts Integration to Enhance Common Core"

[22] "Weschler's Wonder Cabinet: Day-Long forum hosted by Occidental College, LA" (Lecture, April 24, 2010) http://oakesoakes.com/category/exhibitions/current/

# Chapter 2

## Museums and Arts Integration

The idea of arts and science integration has been of special interest to art museum educators because they feel that they are in a perfect position to provide resources to help teachers integrate the arts into STEM and to fill the gap in the education of many students today. Museums are often the kind of institutions educators look to in order to enhance what is taught in the classroom. A schoolteacher teaching about Renaissance culture might take the students on a field trip to the Metropolitan Museum of Art to look at its collection of Renaissance art works. However, most STEM teachers would not think of taking their classes to an art museum because art is thought of as being irrelevant to science. Yet more of these teachers are realizing the value of arts integration to enhance science learning. They see that, for example, a landscape painting could be a basis of a geography lesson, a portrait of Galileo could start a discussion on his contribution to science, and a humidity gauge by an ancient manuscript could start a discussion on the science of art conservation. By the same token, of course, a science center might spark a discussion on the importance of the aesthetics of a work of engineering. The arts and sciences are not mutually exclusive and a student needs experience in both fields to have a full education.

As such, teachers are reaching out to museums to help fill in the art aspect of education left out by STEM. Museums are being asked to help enhance school curricula by providing arts integration and also to provide professional development resources to educators. As will be seen in the case studies below, this author had the opportunity to discuss arts integration with three professional museum educators. All three responded that their museums had been approached by schools about developing integration lessons.

Museums also have a strong imperative to support their communities and very often this imperative is fulfilled through educational programing. By offering arts integration curricula, a museum supports its community and maintains its own relevance. There is also potential to grow new communities of museum visitors as museums involved in arts integration in partnership with schools are often reaching new audiences of underserved populations. In 2011, a report by The President's Committee on the Arts and the Humanities noted that,

> Recent analyses revealed that the schools with students who could most benefit from the documented advantages of arts strategies are often those that either do not recognize the benefits of arts education or do not have the resources to provide it to their students. Current budgetary crises as well as the narrowing of curricula have forced some schools to curtail arts programs when they are most needed. This situation highlights the growing disparity between those who are able to take advantage of the benefits of arts education, and those who are not.[23]

To illustrate the value museums can provide to learning, it is interesting to review a survey conducted in 2013 by the Crystal Bridges Museum of American Art in Bentonville, Arkansas. This study shows the importance of museums to schools, especially in terms of field trips. This survey showed that seventy to eighty-eight percent of students, depending on the artwork discussed, remember factual information about the work weeks after the visit. These visits increase critical thinking skills by nine percent in students who have been

[23] M. Christine Dwyer, "Reinvesting in Arts Education," *President's Committee on the Arts and the Humanities* (May 2011): accessed December 10, 2014, http://www.pcah.gov/sites/default/files/photos/PCAH_Reinvesting_4web.pdf

on trips to this museum. This number can go up to thirty-three percent in rural schools and eighteen percent in high poverty schools. At a time when schools are utilizing the resources offered by the museum less and less, this survey shows that museums can enhance students' education.[24] Using this survey, teachers can show their administrators the importance of museums to the education of their students. Too often, school administrators have to be focused on the STEM subjects and standardized testing, however, seeing the information gained from the survey, the hope is that teachers could convince administrators of the importance of museums as valuable partners in educating their students. This will become especially true as more museums adopt an art integrated approach to education.

Economics are also important in the discussion of why museums should be leaders in arts integration. Museum funding is decreasing and a still stressed economy continues to put pressure on museums.[25] Despite these funding concerns, museums still have the expectation to support their communities. A 2010 report by the American Museum Association stated that, "In a time of financial stress for museums and economic hardship for many of their users, museums have become increasingly important to the communities they serve."[26]

By providing arts integration opportunities for schools, a museum both supports its community and increases opportunities to attract more grant money. For instance, the

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[24] Jay Greene, Brian Kisida and Daniel Bowen. "The Education Value of Field Trips," EducationNext, Vol 14, NO. 1 2014) accessed November 8, 2014. http://educationnext.org/the-educational-value-of-field-trips/

[25] Daniel Grant, "How do museums pay for themselves these days?" HuffPost:Arts and Culture, September 7, 2012, accessed November 13, 2012, http://www.huffingtonpost.com/daniel-grant/museum-cuts_b_1816309.html

[26] "Service Despite Stress: Museum Attendance and Funding in a Year of Recession," American Association of Museums, February 2011 accessed November 13, 2014, http://aam-us.org/docs/research/acme-2010.pdf?sfvrsn=2

Institute of Museum and Library Services (IMLS) offers a multitude of grants for museums for work in the areas of 21st Century Skills, community engagement, education support and innovation, all topics which are related to arts integration. The IMLS grants aim to "encourage and support museums in carrying out their public service role of connecting the whole of society to the cultural, artistic, historical, natural, and scientific understandings that constitute our heritage and to encourage and support museums in carrying out their educational role as core providers of learning and in conjunction with schools, families, and communities."[27] Recent grants awarded include $95,000 for the Staten Island Children's Museum in Staten Island, NY, to design a learning space specifically to address STEM and arts integration topics; $88,010 to The Palo Alto Center in Palo Alto, CA, to support an arts partnership integrated with biology at a local zoo and $88,364 to the Textile Museum in Washington, D.C., to design an interactive curriculum to promote the understanding of textiles through arts, culture and mathematics.[28]

The IMLS is just one source for funding for integration efforts. Other organizations such as The National Arts Education Association offer grant opportunities.[29] The U.S. Department of Education does so as well, through their "Arts in Education - Model Development and Dissemination Grants Program."[30] Museums are also likely to benefit from increased revenue generated from school museum visits and by offering professional educator workshops to teachers.

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[27] Exhibiting Public Value: Government Funding in the United States: December 2011 Report (Washington D.C: Institute of Museum and Library Services), accessed November 13, http://www.imls.gov/assets/1/AssetManager/MuseumPublicFinance.pdf

[28] "Grant Search," Search Awarded Grants, accessed November 13, 2014, http://www.imls.gov/recipients/grantsearch.aspx (Search Institution names)

[29] "Grants and Opportunities," National Art Education Association, accessed December 10, 2014, http://www.arteducators.org/grants

[30] "Funding: Arts in Education - Model Development and Dissemination Grants Program," accessed December 10, 2014, http://www2.ed.gov/programs/artsedmodel/index.html

While discussing the economics of museums, Ray Mark Rinaldi, a fine art critic for the Denver Post newspaper wrote,

> But what if the money went toward the very core of their mission: educating the public about art. Schools are in deep trouble, arts education has fallen by the wayside, and that's a tragedy for communities overall who need thinking citizens to thrive, and museums in particular, which need knowledgeable customers to survive…Public schools are not the responsibility of nonprofit museums. But education is, and when you are sitting on money while kids are falling behind, it's time to step up.[31]

Robert Stein, Deputy Director of the Dallas Museum of Art is a strong advocate of museums doing more for education. He writes that without meaningful education offerings, museums "risk being relegated to the periphery of contemporary society as mere treasure houses for the wealthy in need of a tax-break." He further stated that,

> As repositories of the world's greatest creative endeavors, museums provide a tremendous workshop for exploring creative genius both past and present. If one were to look for a place where creativity could be learned, studied, examined, and replicated in all its forms, you could scarcely do better than by exploring the collections at your local museum.[32]

In summary, by engaging in arts integration, a museums can help meet the needs of its community and thus maintain its relevancy as a valuable community partner. As well, in

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[31] Ray Mark Rinaldi, "Five ways to rethink the American Museum," The Denver Post, November 24, 2013 accessed November 13. 2014, http://www.denverpost.com/theater/ci_24574249/rethinking-american-museum?source=infinite

[32] Robert Stein, "Museums...So What?" Code | Words: Technology and Theory in the Museum, June 4, 2014, accessed November 13, 2014, https://medium.com/code-words-technology-and-theory-in-the-museum/museums-so-what-7b4594e72283

an economy that has caused many funding sources to dry up, a museum can use arts integration as a new avenue for grant funding. Finally, a museum can capitalize on its collections and expertise to meaningfully provide education for the 21st century.

What follows are five case studies that illustrate how museums are utilizing arts integration as an essential part of its education curriculum offerings. The case studies include two fine arts museums, a glass museum, a math center and a performing arts center. Among the offerings of these institutions are opportunities for arts integrated learning involving all types of arts – visual arts, dance, music and dramatic arts. While the arts integration that will be discussed is not perfect in all respects, the efforts of these museums do serve as very good examples for other museums and cultural institutions and for school educators looking for arts integration resources.

# Chapter 3

## Case Study: J. Paul Getty Museum

### Introduction

The first case study is an arts integration program developed at the J. Paul Getty Museum, located in Los Angeles, California. The Getty Museum's mission is as follows:

> The J. Paul Getty Museum seeks to inspire curiosity about, and enjoyment and understanding of, the visual arts by collecting, conserving, exhibiting and interpreting works of art of outstanding quality and historical importance. To fulfill this mission, the Museum continues to build its collections through purchase and gifts, and develops programs of exhibitions, publications, scholarly research, public education, and the performing arts that engage our diverse local and international audiences.[33]

This case study will look at an attempt by the Getty to fulfill its mission of public education through a collaboration with science and art educators. The Getty Museum's arts integration program owes its excellence to three factors. First, the lessons were conceived to address three levels of educational learning: beginners, intermediate and advanced. Thus the programming allows educators to tailor the lessons to the needs of their learners. Second, the lessons specifically address national education standards. This allows educators to select specific rationales to their lessons choices to meet their curriculum needs. Finally, these lessons stress that art and science teachers should work together in implementing these lessons. This case study will discuss two of the projects in *Art and*

[33] "About the J. Paul Getty Museum," About the J. Paul Getty Museum, accessed November 14, 2014, http://www.getty.edu/museum/about.html

*Science: a Curriculum for K-12 Teachers* and relate this programming to the discussion of arts integration education.

**Case Study**

In 2007, museum educators at the J. Paul Getty Museum, along with conservators, curators, scientists, and teachers, created a series of lessons using objects from the museum's collections as a basis to explore areas where the arts intersect with the sciences.[34]

Sandy Rodriguez, an Education Specialist for School Audiences at the Getty, was interviewed for this thesis about the development process of this curriculum. She said that while the Getty has produced over two hundred resources and lessons for K-12, a survey of their audience showed that there were some needs of schoolteachers that the museum was not filling. The survey let them know that, while the audience found strength in their publications, they saw a need for more interdisciplinary programs, particularly programs in which the sciences were more fleshed out. In August of 2005, the Getty educators began to brainstorm ideas about how to fill this gap in their curriculum. After this, they recruited an advisory group of K-12 teachers. The Getty staff pitched the ideas they had come up with and then asked the teachers to help them determine what was realistic for classrooms. Rodriquez said the process was lengthy and took one and a half to two years to complete. The final content of the new curriculum was co-authored by two Getty museum educators with each lesson being weighed in on by the teacher's advisory group. Getty curators and conservators also had a voice as content editors. All told, Rodriquez stated that thirty-two experts provided input into the content, revisions and feedback. Rodriquez said that the

[34] Art & Science: A Curriculum for K-12 Teachers from the J. Paul Getty Museum. Los Angeles, CA: J. Paul Getty Museum, 2013. Print. Pg. 5

Getty is fortunate because they have scientists in conservation and curators as in-house resources, which was very useful in this process. This process was repeated when the lessons were revised in 2013.[35]

The result of this process was *Art and Science: a Curriculum for K-12 Teachers*, a manual produced by the Getty Museum as a resource for teachers. In a discussion at the Mid-Atlantic Association of Museums Conference in 2013 led by Steven Kern, then Executive Director of the Everson Museum, Kern referred to this broad collaboration as an "unnatural partnership" but one that allowed for new ideas and considerations for educators.[36] The thirty-six lesson plans that are part of *Art and Science: A Curriculum for K-12 Teachers* cover a variety of scientific fields such as chemistry, biology, and entomology. Each lesson includes handouts, resources for continued learning, background information about the art work and specific questions for the teacher to ask the students about the artwork to be discussed.[37] The background information and questions allow science teachers who do not have experience with art or art history to explain to students how and where to focus their attention. In 2013, the Getty made *Art and Science* the first of its curriculum to be released nationwide.[38]

One of the strengths of the Getty curriculum is that it stresses the importance of art and science teachers working together in implementing these lessons.[39] This interdisciplinary collaboration will model for the students how the arts and sciences are related. The lessons are focused on the science of how art is produced or conserved. The

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[35] Sandy Rodriguez, Interview by Author, November 4, 2014.
[36] Kern, Steven. "Generating STEAM: Art Museums and STEM Education." Mid-Atlantic Association of Museums. Washington DC. 21 Oct. 2013. Lecture.
[37] Art & Science: A Curriculum for K-12 Teachers
[38] Theresa Sotto, Jerry Podany, and Lilit Sadoyan, "Art &Science" (webinar), May 22, 2013, accessed October 24, 2014, http://www.getty.edu/education/teachers/professional_dev/webinars/webinars_index.html.
[39] Art & Science: A Curriculum for K-12 Teachers. Pg. 5

Getty educators also stress the scientific skills of experimentation and investigation and how these skills are related to art.[40] Learning how to develop and conduct experiments is one of the foundations of scientific learning.

*Art and Science* corresponds to both Californian and national standards for education, therefore, these lessons can be used by teachers across the country.[6] This allows teachers to show school administrators that, while they are working outside of what is considered to be the traditional subject division of disciplines - Science, Math, History, Language and the Arts, the lessons still meet the stringent learning standards that are required. In 2012, the Getty museum completed an evaluation of their educational programming and found that 76.5percent of respondents assessed relevancy to standards as either very important or essential to their decision to teach a topic.[41]

Another strength of *Arts and Science* is its flexibility, which allows lessons to be added or taken away. A recent Getty exhibition "Maria Sibylla Merian & Daughters: Women of Art and Science" inspired the Getty to develop a workshop for teachers related to this exhibition which featured books, prints and watercolors created by Merian and her daughters in the late 1600's and early 1700's. These women are credited with improving the artistic standards of natural history illustration through their botanical drawings. Merian also is said to have transformed the field of entomology, the study of insects, through her careful scientific study and extraordinary scientific illustrations featured in her famous book, *The Insects of Suriname*.[42] For the full day workshop the education staff at the

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[40] Art & Science: A Curriculum for K-12 Teachers. Pg. 5

[41] Theresa Sotto, "Summary Report of Survey Findings: Teacher Programs: Assessing the Getty Museum's Online Resources for K-12 Teachers," *J. Paul Getty Museum*, (April 2012) October 24, 2012, http://www.getty.edu/education/museum_educators/downloads/getty_online_survey_report.pdf., Pg. ii

[42] "Maria Sibylla Merian & Daughters: Women of Art and Science," Getty Center, accessed December 1, 2014, http://getty.edu/art/exhibitions/merian/

Getty adapted their resources to model how to use the content. The staff also showed the teachers how other artwork could be added to the already existing content.[43] This shows that these lessons are not stagnant. They can change and continue to grow as the teacher sees fit.

Each topic in *Arts and Science* has lessons for three levels of education, beginners, intermediate and advanced.[44] Thus the lessons can be used from Kindergarten to twelfth grade and allow teachers to tailor the programming to the needs of their students. When considering lessons for use in their classrooms, 95.7 percent of teachers who responded to the Getty evaluation rated the appropriateness to their students' academic level the number one factor in their choice of lessons.[45]

**Evaluation and Criticism of *Art and Science: A Curriculum for K-12 Teachers***

As mentioned above, in 2012 the Getty produced an evaluation of their online resources for science and art programming by doing a survey to which 374 people responded. While not specifically focused on *Art and Science: A Curriculum for K-12 Teachers*, the study provided important feedback on this work. *Art and Science* was found to be the most popular of the Getty's three current curriculum books, with almost seventy percent of evaluation respondents reporting that they had either used or adapted *Art and Science* in their classrooms. The survey found that these lessons are especially popular with 4th and 5th- grade teachers. Almost eighty percent of the responding teachers in those grades reported having utilized these lessons. In general conclusions about Getty programming, seventy percent of the teachers surveyed in this evaluation believe that *Art*

[43] Rodriguez, Interview by Author, November 4, 2014.
[44] Art & Science: A Curriculum for K-12 Teachers. Pg. 5
[45] Sotto, "Summary Report of Survey Findings". Pg. 20

*and Science* effectively helps students make connections between art and other disciplines which is a critical component when considering arts integration initiatives.[46]

The Getty evaluation also noted negatives to their overall education programming, including that of the *Art and Science* format. Teachers expressed concerns about the lessons not always being practical for large class sizes. Concerns about material costs and availability were also noted as well as concerns about time constraints restricting their decision to choose lessons from the *Art and Science* curriculum. Teachers also expressed a desire to see the Getty's materials connect more directly to current school textbooks. For pre-K-3rd grade and high school teachers, there was also notable disappointment concerning the lack of engagement with the artwork discussed in the lessons and also, the lack of understanding of the subject matter concepts intended with the *Art and Science* lessons. 4th-8th grade teachers responded more positively in these areas. [47]

Taking cues from this 2012 evaluation, the Getty looked to improve the aspects of the program that were criticized and to further expand and improve its programming and lessons such as *Art and Science*. One area they hope to expand is the integration of mathematics into its curriculum. They believe that the overall results of their review demonstrate that the arts integration strategy is successful and they hope to keep improving the lessons to maximize their impact to educators and students.[48] As a direct result of this feedback, the Getty revised the *Art and Science* curriculum in 2013.

In this author's interview with Getty educator Sandy Rodriquez, this 2013 revision was discussed. Rodriquez said that the second edition of *Art and Science* was developed by

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[46] Sotto, "Summary Report of Survey Findings". Pg. 28
[47] Ibid. Pg. 9
[48] Ibid. Pg. 29

herself and fellow Getty educator Teresa Sotto. Rodriquez and Sotto reviewed the original publication and determined that there was too much science and that the lessons were not integrated enough. Rodriquez said that upon critical review it appeared that the lessons used art but never in a way was that truly arts integration. Both educators felt that in the second edition there needed to be more actual integration. Reviewing the survey and also downloads and page view information from the Getty website, they also noted that teachers wanted more resources and handouts. Rodriquez said, "The original had strengths - but we teased out more."[49]

According to Rodriquez, teacher feedback to the revisions has been very positive. She said that people are very excited to frame the collection in a creative way for students and that the second edition is "loaded with ideas". Ultimately, Rodriquez notes the strengths of *Art and Sciences* is that students are compelled to look at objects through a variety of lenses and to see that the intersection of art and science is useful. She also said that *Art and Sciences* offers a great opportunity to students to experiment with materials.[50]

To further expand the understanding of the Getty *Science and Art* programming, two lessons will be reviewed.

**Lesson Review 1: Fighting Corrosion to Save an Ancient Greek Bronze**

The first lesson plan that will be explored is *Fighting Corrosion to Save an Ancient Greek Bronze*. This lesson is important as it demonstrates the strengths of the Getty program with respect to adherence to national standards as well as to grade level programming. The lesson focuses on an ancient Greek bronze entitled *Victorious Youth*, found by fisherman in international waters off the coast of Italy after being under water for

[49] Rodriguez, Interview by Author, November 4, 2014.
[50] Ibid.

an estimated two thousand years. When found, the statue had developed a rough outer surface due to corrosion and to the accretion of biological and mineral materials.[51] Corrosion occurs because bronze is a copper alloy. The process that combines the copper ore with other metals makes the bronze less chemically stable; it wants to go back to the copper ore state. Overtime, a mineral layer develops on the surface of the bronze that is called patina. *Victorious Youth* was especially affected by this chemical process because of its exposure to salt water. The water created a problem known as bronze disease, whereby the copper ions in the bronze join with the chloride in the salt water causing a chemical reaction that creates cuprous chloride, a greenish blue powder, and hydrochloride. This is a continuous process and can eventually destroy the whole object.[52] From a science standpoint, the lesson focuses on what caused the metal to change and the processes used to stop the disease from destroying the piece. From an art perspective, the focus is on how to look for details in a work of art and involves an analysis of the pose of "Victorious Youth". The youth is posed crowning himself with an olive wreath, identifying him as an Olympic victor and symbolizing his victory.[53] The youth in the statue is also importantly posed in "contrapposto", meaning that he is standing so that his weight rests on one leg. With this weight shift, his hips, shoulders, and head tilt, which gives the work a more natural, relaxed pose.[54] Contrapposto was invented in Greece around the 5th century and is a defining trait of Classical Greek sculptures from those of the earlier Archaic period.[55]

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[51] Art & Science: A Curriculum for K-12 Teachers. Pg. 96
[52] Theresa Sotto, et al, "Art &Science" (webinar)
[53] "Victorious Youth," The J. Paul Getty Museum, accessed December 4, 2014, http://www.getty.edu/art/collection/objects/7792/unknown-maker-victorious-youth-greek-300-100-bc/
[54] Encyclopedia Britannica, s.v. "Contrappasto," accessed December 3, 2014, http://www.britannica.com/EBchecked/topic/135385/contrapposto
[55] Fred S. Kleiner and Christian J. Mamiya, Gardner's Art Through the Ages: A Concise History of Western Art (Belmont, California: Thomson Wadsworth, 2008), 66.

This lesson is designed to be used at three different grade levels. The beginner level is for students from 3rd to 5th grade. This lesson focuses on looking at the pose of *Victorious Youth* and has the students observe how a penny that has been placed in salt water changes over the course of a week's time. This will allow students to see the effects of corrosion on the penny. Students will document what they observe throughout the week. They will then be introduced to *Victorious Youth*, in its pre-conservation form. They will be asked to discuss what they see. Student will also learn about bronze disease, a chemical reaction that causes the deterioration of bronze sculptures. Students will then be asked to compare this to the conserved statue and will learn that certain chemicals allowed conservators to neutralize the corrosion.[56] They will also learn about how the Getty continues to minimize the damage to the sculpture caused by the bronze disease while it is on display. They have a specially designed room that has extremely low humidity, about forty percent, to limit the effect of water on the sculpture.[57]

Through the use of experimentation, observation, and discussion, the beginner level lesson meets the National Sciences Content Standards for grades kindergarten to 4th grade in the areas of "Science as Inquiry" and "Physical Sciences". National Art Standards found in this lesson include "Choosing and Evaluating a Range of Subject Matter, Symbols and Ideas" and "Making Connections between Visual Arts and other disciplines."[58] Interestingly, the national standards included highlight the expectations given in these standards for connections to be made between art and other disciplines and the push for differing

[56] Art & Science: A Curriculum for K-12 Teachers.
[57] Theresa Sotto, Jerry Podany, and Lilit Sadoyan, "Art &Science" (webinar).
[58] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers. J. Paul Getty Museum, 2013. Web. 13 Oct. 2014.

subjects to be connected. Thus it can be seen that many of the lessons in *Art and Science* meets this expectation by connecting art works to scientific topics.

The intermediate level lesson builds on the beginner level by having the students look at the periodic table of elements that are a part of the corrosion process. They also learn about chemical compounds, alloys and conductivity. The lesson also integrates art learning through an analysis of the pose of the sculpture and similar to the beginner lesson, challenges the students to make observations about the statue and its symbolism of the importance of victory in Greek society. Students are asked to expand upon the discussion to consider how they think the statue ended up in the bottom of the ocean.[59]

At the intermediate level, this lessons meets the needs of the National Science Standards of "Structure of Matter" and "Investigation and Experimentation". National Art Standards that are met include "Choosing and Evaluating a Range of Subject Matter, Symbols and Ideas" and "Understanding Visual Arts in Relationship to History and Cultures."[60]

The advanced level of *Fighting Corrosion* is geared towards high school students and incorporates the chemistry lessons from the intermediate lessons and expands this learning to include the oxidation-reduction reactions and chemical reactions that occurred in the statue. Students are asked to consider various methods of conservation available for use with metal materials such as electrolytic, electrochemical, and sodium-sesquicarbonate/vacuum. These different methodologies are explored and the students are asked to make recommendations for what they feel would be the best method to conserve

[59] Art & Science: A Curriculum for K-12 Teachers. Pg 99
[60] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers.

an artwork such as *Victorious Youth*. Their results are then compared to the methodology of conservation used at the Getty.

Art is integrated into this advanced lesson level through discussion of the artistic elements of the statue and the importance of its preservation. Similar to the other lesson levels, symbolism and culture-historical clues can also be discussed.[61]

National Science Standards used at the advanced level of this lesson include "Science as Inquiry", "History and Nature of Science", and "Science and Technology". National Art Standards used in this lesson include "Choosing and Evaluating a Range of Subject Matter, Symbols and Ideas" and "Understanding Visual Arts in Relationship to History and Cultures".[62]

In summary, this lesson uses an art object, a bronze sculpture, to teach students about metal and the effects of different environmental factors on this object. Teachers can use this lesson as a stand-alone lesson or as part of a unit focusing on the basic understanding of chemistry and the elements, as they also have the opportunity to look at the periodic table as a part of this lesson. This lesson is also perfect for collaboration between a science and art teacher. The science teacher can focus on the experiments while the art teacher can use *Victorious Youth* to discuss the symbolism of victory in the piece and the historical significance of this symbolism to Greek culture and art and also, the significance of the contrapposto technique. The art students can design a piece of their own using these ideas. *Fighting Corrosion to save an Ancient Greek Bronze* also allows students to explore art of the past and to understand that many works of art need to be conserved in order for them to stand the test of time.

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[61] Art & Science: A Curriculum for K-12 Teachers. Pg. 100-101
[62] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers.

**Lesson Review 2: Capturing Light: The Science of Photography**

The second lesson to be reviewed to further expand the understanding of the Getty *Science and Art* programming is *Capturing Light: The Science of Photography*. Similar to the previous lesson, it also demonstrates the strengths of the Getty programming in respect to adherence to national standards and to grade level programming.

Like the previous lesson, this topic has three levels; beginning, intermediate and advanced. From a science perspective, the beginning lesson uses a simple pinhole camera to help students understand that light travels in a straight path. They also learn about lines and shapes. Finally, the changes in photography and photographic technology over time are also discussed. The students create their own pinhole camera and learn to use this to create a drawing. The artwork used in this lesson is called *The Emperor's Private Mosque in the Marble Palace, Agra Fort, India,* by Dr. John Murray. This work is of a large waxed-paper negative. Dr. John Murray manipulated the print to make it more appealing and to increase the luminosity of the finished positive print. He used techniques of blocking and bleaching to highlight the mosque interior. He also used a waxed-paper process which allowed him to delay the immediate development of the print and allowed the work to have more translucency than other commonly used paper negative methods. This process involves rubbing wax into the paper negative before completing the exposure process. The wax creates a smoother surface and reduces blurring. This gives both the negative and the final print finer detail and highlights the surroundings behind the mosque. This artwork is used to teach the students about historical methods of documenting architecture and to encourage them to do their own documentation of their surroundings.[63]

[63] Art & Science: A Curriculum for K-12 Teachers Pg. 55-58

National Science Standards addressed in the *Capturing Light* lesson at the beginner level include "Science and Technology" and "Physical Science". National Art Standards addressed include "Artistic Perception" and "Historical & Cultural Context."[64]

At the intermediate level, the lesson includes the learning from the beginning level of the lesson and adds the concept of light refraction through the use of a convex lens. Several historical photographs are added at this level to expose students to various types of photography such as metal daguerreotype, glass ambrotypes and paper salt prints. The chemical processes are discussed for each type of photography and the quality of the image is also discussed.[65]

National Science Standards addressed in the intermediate level of *Capturing Light* include "Science as Inquiry" and "Physical Science". National Art Standards addressed for this level include "Artistic Perception" and "Understanding the Visual Arts in Relation to History and Culture."[66]

The advanced level of *Capturing Light* expands the discussion of light and how light can be used and manipulated by artists and photographers. This level also specifically focuses on elements of physical sciences, in this case, light waves and their characteristics. Students learn how light travels, how certain lenses can affect the light waves and how different materials can be used in photography and they explore the different results of the use of these various materials. They also discuss photo composition and practice these concepts using digital or phone cameras to test out lighting and angles. Once this is done, the students select a subject for a photograph that they will take using a pinhole camera

[64] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers.
[65] Art & Science: A Curriculum for K-12 Teachers. Pg. 60
[66] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers.

that they have made themselves. They develop this photo by placing the photosensitive paper in water. They then compare these photos to a digital image of the same composition. After this, they experiment with the ways in which their image looks if they take a picture of a dull or a reflective object. They compare the negatives they have made to *The Emperor's Private Mosque* in order to understand how the mosque looked at the time Dr. Murray took the photograph. They also experiment with the use of lenses and experience how the light will react to a lens placed over the pinhole.[67]

At the advanced level, *Capturing Light* meets the National Science Content Standards of "Science as Inquiry" and "Physical Science" for ninth through twelfth grade. In the Visual Arts, it meets the standards of "Understanding and Applying Media, Techniques, and Processes", "Using Knowledge of Structures and Functions", and "Reflecting Upon and Assessing the Characteristics and Merits of Their Work and the Work of Others". *Capturing Light* also meets the national standard on "Making Connections between Visual Arts and Other Disciplines." [68]

In summary, this lesson creatively integrates art learning with science. *Capturing Light* is meant to teach science through observation and experimentation. Teachers can use this lesson to show students how creativity is necessary when developing scientific experiments. The lesson states that there are many steps to the *Capturing Light* experiment. The first is to just take a photograph, the second to take photographs of objects with different kinds of surfaces. It also says that students can take pictures through a lens or with an object inside their camera.[69] Each of these variations will create a different result.

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[67] Art & Science: A Curriculum for K-12 Teachers. Pg. 62-63
[68] "Standards Charts." Art and Science: A Curriculum for K-12 Teachers.
[69] Art & Science: A Curriculum for K-12 Teachers.

Students will use these results to understand how light waves travel. In order to develop the students' creativity, the teacher can give students random objects that fit the requirements of the lesson plan and have the students discover how to create their own experiment. Another creative effort that could be done by the teacher could be using the students' photographic experiments to create an art show and through this, emphasizing the importance of composition and artistic merit to their students.

**Lesson Review Summary**

The photography lessons are good examples of how museums can utilize the arts and sciences in collaboration with each other. Arts integration education and its implementation in museum education programming for schools is still in the early stages. *Art and Science: a Curriculum for K-12 Teachers* provides a good model for how arts integration can be used in the museums. While the lessons in this curriculum are designed for a classroom setting, a museum could use them to model a multi-week course on its premises. These lessons could even be condensed so another museum could use *Art and Science* as a model of using an art object to teach about science on a school or family tour.

The Getty is modeling ways for schools and other museums to blend art and science. Both lessons discussed above offer a starting point for teachers to use the arts to teach science to their students, however; both lessons allow for further collaboration between these disciplines. In order to enhance these lessons, teachers can modify the existing content and allow student to use their creativity to design an experiment, for instance, looking at similar conservation projects other than the one discussed in *Fighting Corrosion*. In "Capturing Light", students are asked to look at the composition of the photographs they are taking with their pinhole cameras. However, this in only briefly mentioned. The

educator could use this as a springboard for further discussion of composition and the elements of balance, contrast and proportion.

**Case Study Conclusion**

With *Art and Science: a Curriculum for K-12 Teachers*, the Getty has created a model for arts integration education to be used by art museums and schools across the country. The Getty's programming shows that art and science enhance each other when used in concert. The lessons in *Art and Science* also serve as a way for the Getty to develop relationships with new audiences. Science educators and people interested in learning more about science will be drawn to the Getty through this curriculum. Science educators will look to the Getty as a way to diversify their courses while still focusing on their discipline. This is especially true because the Getty Museum offers the opportunity for teachers to design their own gallery activities.[70] Students interested in science who never thought about going to an art museum due to the traditional idea that these two disciplines are in opposition, will discover the opportunities to discuss and learn about science and art at the Getty.

One of the major benefits of arts integration education is the emphasis it places on creativity. Critics of STEM believe that this math and science based curriculum does not make room for creativity. The lessons in *Art and Science: A Curriculum for K-12 Teachers* show that educators have an opportunity to debunk this thinking. These lessons allow students and educators to explore their creativity though scientific experimentation and observation though the integration of the arts.

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[70] "Create Your Own Gallery Lesson, Villa (Education at the Getty)." Planning a School Visit. J. Paul Getty Museum. Web. 13 Oct. 2014.

# Chapter 4

## Case Study: The National Museum of Mathematics

### Introduction

The following case study will show how exhibit designers and educators at the National Museum of Mathematics (MoMath) are integrating art and mathematics programming. It will show how MoMath can serve as a model for science museums to incorporate art and creativity into its math programming.

MoMath is located in Manhattan. It is the only math-centered museum in the United States. The museum's mission reads,

> Mathematics illuminates the patterns that abound in our world. The National Museum of Mathematics strives to enhance public understanding and perception of mathematics. Its dynamic exhibits and programs stimulate inquiry, spark curiosity, and reveal the wonders of mathematics. The Museum's activities lead a broad and diverse audience to understand the evolving, creative, human, and aesthetic nature of mathematics.[71]

MoMath is the only dedicated math museum in the United States.[72] It developed in response to the closing of the Goudreau Museum in New Hyde Park, NY. The Goudreau Museum of Mathematics in Art and Science was founded by Bernand Goudreau, a former engineer and math teacher and sought to "promote and encourage interest in mathematics for everyone, regardless of age or mathematical background."[73] This was a small museum

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[71] "About," Museum of Mathematics, accessed October 18, 2014, http://momath.org/about/
[72] Ibid.
[73] Goudreau Museum of Mathematics in Art and Science, Accessed November 1, 2014. http://www.mathmuseum.org/

that offered visitors the opportunity to build a math model, to explore games, work with puzzles and to view demonstrations on how math influences the arts and sciences.[74]

With the closing of the Goudreau, a mixed group of math educators and corporate professionals led by Glen Whitney, a former math scholar and professor at the University of Michigan, recognized that, despite the incredible demand for hands-on math programming, the United States was left without a math museum.[75] This group began to explore a new math museum, one that would expand upon the ideas of the Goudreau in both its scope and methodology.[76] The result was the opening of MoMath in 2012. This museum is meant to show the fun and creative side of math. The museum's goal is to turn math into play.[77] According to Whitney, "Math touches on so many things in the world around us there's a connection between mathematics and music, connection with engineering, between mathematics and business, between mathematics and art. And we want to show all those parts of mathematics here."[78] MoMath lists among it accomplishments its place as Manhattan's only hands-on science center (their own term), the creation of its popular nationally touring *Math Midway* exhibition, its *Math Encounters* and *Family Fridays* presentations and the opportunities it provides to increase the appreciation of mathematics for students, teachers, and the public.[79]

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[74] Goudreau Museum of Mathematics in Art and Science,

[75] Tanya Rivero, Nick Poppy, Mary-Rose Abraham and Christina Lopez, "No numbers here: Math Museum Founder Glen Whitney", January 28, 2013 accessed November 1, 2014, http://news.yahoo.com/%E2%80%98no-numbers-here%E2%80%99--math-museum-founder-glen-whitney-012155888.html

[76] "About," Museum of Mathematics

[77] Jennifer Maloney, "New Museum Really Adds Up," *The Wall Street Journal* (December 12, 2012) accessed October 18, 2014, http://online.wsj.com/news/articles/SB10001424127887323981504578175390749666204#printMode

[78] Tanya Rivero, et. al,, "No numbers here: Math Museum Founder Glen Whitney"

[79] "About," Museum of Mathematics

The Museum of Mathematics wants to change the way people think about math. It is aimed at a broad audience, not at visitors with degrees in mathematics. As its mission statement indicates, it focuses on the creative and aesthetic nature of math. In its programming and exhibitions, math and art intersect seamlessly. This case study will discuss several of the exhibits at MoMath.

**Exhibit 1: Compounding Visions: the Art of Ryan and Trevor Oakes**

The Museum of Math's *Composite* gallery is aimed at showing "the breadth of human pursuits that mathematics can illuminate."[80] Designed as a temporary exhibit space, the *Composite* gallery's first exhibition was titled "*Compounding Visions: the Art of Ryan and Trevor Oakes.*" [81] At first glance, the artwork on display seemed unrelated to mathematics but the sculptures in this exhibit were based on specific algorithms.[82] According to the Merriam Webster dictionary, an algorithm refers to a set of steps used to solve a mathematical problem. This exhibit displayed a series of sculptures made of pipe cleaners. In one example of these sculptures, there were two colors of pipe cleaners, green and orange. The sculpture is intricately woven into a shape reminiscent of a sea anemone.[83] In designing this sculpture, the algorithm process allows that only the green pipe cleaners connect to other green pipe cleaners, and that the orange pipe cleaners only connect with other orange pipe cleaners. The pipe cleaners are woven together to create a "repeating fractal-generating algorithm."[84] Or more simply, the pattern varies, and then each variation

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[80] "Composite: the Gallery at MoMath," Museum of Mathematics, accessed October 17th, 2014, http://momath.org/fieldtrips/composite-gallery/

[81] Ibid.

[82] Ryan and Trevor Oakes, "A Description of the Algorithmic Recipe for this Sculpture", Museum of Mathematics: pg. 1, accessed October 17th, 2014, http://momath.org/fieldtrips/compounding-visions-algorithms/

[83] Ibid.

[84] Ibid.

eventually repeats itself. [85] The exhibition is explained through interpretive signage, videos and the sculptures on view.

In addition to the pipe cleaner sculptures, the *Compounding Vison* exhibition also featured a number of drawings created by the Oakes brothers, Ryan and Trevor. Trained both in art and mathematics, the brothers collaborate on art that showcases mathematic principles. The drawings in the exhibit are done in various media (e.g., pencil and paint) and are done on concave canvases produced by a machine that was created by the brothers.[86] This machine is designed to incorporate human perception created by our binocular vision into the drawing and the resulting drawing gives the two-dimensional surface of the work the illusion of three dimensions.[87] The paper is placed onto the machine in strips, leaving a gap open. The Oakes brothers will deliberately cross their eyes in order to view both of the perspectives human eyes receive. Focusing on one eye's field of vision, the brother will draw that image. Once completed, he will turn his attention to his other eye and do the same process.[88] The brothers believe that this way of creating art produces an end result that is more similar to how people actually view the world than when a drawing is on a flat surface, as the flat surface distorts the perspective of the piece.[89] The Oakes brothers use the science of how people see to create a new type of perspective drawings. The artwork that is created through this process is the result of scientific thinking and experimentation. The curved canvas is a unique way to display a drawing and draws viewers in. Through a non-traditional manner, this exhibits challenges

[85] Oakes and Oakes, "A Description of the Algorithmic Recipe for this Sculpture",
[86] Douglas Capraro, "Crossed Eyes and Compounding Visions at NYC's MoMath," *Untapped Cities* (June 12, 2014) accessed October 18, 2014. http://untappedcities.com/2014/06/13/compounding-visions-and-crossed-eyes-at-nycs-momath/
[87] "Current Exhibitions," Oakes and Oakes, accessed November 20, 2014, http://oakesoakes.com/category/exhibitions/current/
[89] Capraro, "Crossed Eyes and Compounding Visions"

viewers to think differently about elements of geometry such as depth, space, spheres and lines.

The Oakes' brother exhibit closed in September 2014 and future exhibition in this space are being developed. However, the *Composite* Gallery will continue to feature exhibits like "Compounding Visions" that explore the points where art and math intersect. MoMath is currently seeking proposals for art that explores "the intersection between the arts and mathematics, helping people realize that a mathematical perspective can enrich their perception of the world around them."[90]

**Exhibit 2: PolyPaint**

MoMath also features a permanent exhibition that explores the intersection of art and math called "PolyPaint." This exhibit allows visitors to explore the mathematical concepts of symmetry through an activity of digitally "painting" patterns on a large computer screen.[91] The visitor to this exhibit will take a digital "paintbrush" (which is actually a stylus) and begin drawing on the computer screen. They test out the "canvas" first. The stroke they make is repeated through the entire frame.[92] This exhibit is meant to educate visitors about the four different types of symmetry: reflectional, translational, rotational, and glide. These four types of symmetry can be combined into seventeen different combinations.[93] Visitors will choose one of these combinations and explore how different combinations allow the same basic painting strokes to create a variety of different patterns. Visitors can gain more knowledge about the seventeen possible types of

[90] "Composite Gallery Application," Museum of Mathematics, accessed October 17th, 2014, https://in.momath.org/civicrm/event/info?reset=1&id=257
[91] Observation of Museum of Mathematics, October 18, 2014
[92] Ibid.
[93] "PolyPaint", viewed October 2014, Museum of Mathematics, New York City

symmetry combinations through the reading and diagrams available at a nearby kiosk display. The kiosk displays several patterns and challenges the visitor to guess which of these patterns fits which type of the symmetry combinations.[94] Another fun element of this exhibit is the chance to electronically send your design over to the "Pattern Pants" exhibit and to see your pattern recreated on a virtual piece of clothing.[95] By allowing visitors to explore the concept of symmetry through art, MoMath shows its audience that math appears in unexpected places in their everyday lives – the pattern on their shirt, their reflections, maybe even the wrapping paper on a birthday gift.

**Exhibit 3: Mathenaeum**

"Mathenaeum" is another permanent MoMath exhibit that explores the intersections of math and design. This exhibit focuses on geometric forms and like "PolyPaint", it invites the visitor to create their own digital art work.[96] Starting with a Platonic solid, like a cube, tetrahedron, or an octahedron, the visitor uses the computer to change the solid by expanding and contracting certain sides, perhaps slicing off areas of the solid, and even twisting the solid.[97] The exhibit refers to this as a solid as the visitor is designing a three-dimensional form, while a shape is a two dimensional form. The computer program allows the user to change the surface color of the solid and to add textures; the corners and edges of the new solid can be highlighted and emphasized. Once the solid is completed to the visitor's liking, they can submit their work through the computer to be shared with other museum goers. Throughout the day, the submissions will be voted on by guests and the newly created solid form with the most votes will be 3D printed and placed outside the

[94] "PolyPaint"
[95] Observation, Oct, 2014
[96] Ibid.
[97] "Mathenaeum", viewed October 2014, Museum of Mathematics, New York City

exhibit.[98] Through this exhibit, visitors are experimenting with geometric forms and concepts in order to make an aesthetically pleasing piece. These solids are three-dimensional forms that are the foundation for creating many types art and design, for instance, drawing, sculpture and architecture.

**Exhibit 4: Tile Factory**

"Tile Factory" allows visitors to explore tessellation. A tessellation is created when a shape is repeated over and over again covering a plane without any gaps or overlaps. [99] Visitors start with a repeating geometric shape, like a triangle or square, which looks like a series of tiles. The visitor then begins to move the lines and angles of the geometric shape, creating a new tile. As the visitor does this, each shape seen in the original tiling changes to match the work being done. Visitors are challenged to create an animal, like a lizard. They are also asked to think about the tile work they see in their everyday lives, like the designs on a patio, or in tiled bathrooms and kitchens or even on a subway wall mural.[100] The exhibit explains that designs such as these are the result of the integration of art and geometry, as are the designs they create at the "Tile Factory".

**Educational Programming: Cross Product**

Not unexpectedly, the educational programming at MoMath explores the integration of math and art. The curriculum of "Cross Product" is one such series of classes. These classes focus on 3D printing. Beginning in October of 2014, these classes will allow participants to design their own sphere using the concepts of trigonometry and to observe the process of 3D printing. Other lessons in this curriculum focus on trigonometry and

[98] Observation, Oct, 2014
[99] "Tile Factory", viewed October 2014, Museum of Mathematics, New York City
[100] Observation, Oct, 2014

ruled surfaces (e.g., curved surfaces like those found on cylinder or cone). Participants will use this knowledge to design their own bracelet.[101] These classes focus on the discussion of the principles of math and it is these principles that are used to create art in some form and often in an unexpected way. Participants are actively using the knowledge they have gained to create a physical object. This hands-on experience reinforces what they have learned. 3D printing also allows participants to explore technology and its role in the creation of art.

**Educational Programming: Family Friday**

MoMath has designed Family Friday to bring families together "to enjoy a diverse array of engaging mathematical activities, promoting interest and enthusiasm among kids and adults alike. Family Fridays feature hour-long programs during which presenters discuss their work for a half an hour, after which they lead an art project. The activities are designed so that all attendees, regardless of age, can participate on an equal footing."[102] Family Friday events can feature math alone but more often incorporate arts integration in order enhance public perception of mathematics, one of the specific areas of focus of MoMath's mission. One recent program observed by this author was called "Bead Geometry". It featured Gwen Fisher, an artist who uses mathematical concepts to create her type of art, bead weaving. Fisher talked briefly about how beads can be used to make any type of three dimensional polyhedron form with convex sides. Convex sides are formed when all vertices or corners of the polyhedron point outwards, away from the center.[103] For this program, she focused on cubes because they are understood by most people. She

[101] "Cross Product: High Resolution," Museum of Mathematics, accessed October 18, 2014, http://momath.org/about/threedimensions/
[102] "Family Fridays," MoMath, accessed November 1, 2014, http://momath.org/family-fridays/
[103] "Convex Polygon," Math Open Reference, last modified 2009, accessed December 5, 2014, http://www.mathopenref.com/polygonconvex.html

briefly explained the process of bead weaving and then showed the audience a series of works created by bead weaving artists. She explained that all of these works utilized the beaded cubes. Once she was done showing these examples, she began to demonstrate the process of making the cube to the audience which then followed her directions. Fisher also challenged those who figured out the basic cube to try making a cube with more than one bead per edge.[104]

While the discussion was interesting, there was not a lot of talk about the math behind the beaded cubes. Fisher did not discuss geometry beyond saying that any polyhedron with convex sides could be created with the beads. Disappointingly, she did not define polyhedron nor explain the concept of convex sides. There was also no discussion of line segments related to geometric shapes.[105] This was a major weakness of the discussion. These mathematical principles are the foundation of her work and they were glossed over during her discussion. This was especially problematic because the advertisement for the event indicated that participants were to learn about line segments and geometric shapes through the discussion and building of geometric structures out of beads and pipe cleaners.

Despite the lack of discussion of actual math principles, the actual making of the beaded cubes seemed to be very popular with the parents and children. While it took the families a few tries to figure out the steps of creating the beaded cubes, MoMath had plenty of staff and volunteers that went around the room to help the families get started. The kids seemed to figure out the project faster than the adults, who became frustrated after not understanding the first step. This author did hear one parent say that she really liked this project and was going to have her children make more at home to create Christmas

[104] Observation of "Bead Geometry", Museum of Mathematics, November 7, 2014
[105] Ibid.

presents for their family members.[106] Overall, this was a good program that was enjoyed by the audience. While there could have been changes made to reinforce the math principles, the process of making the cubes got the parents and children at least thinking about geometry.

Another example of MoMath's Family Friday activities is a program called "Crowd Sourcing Origami". Dr. Jeannine Mosely, a software engineer, creates origami sculptures using business cards. Ms. Mosely and the visitors create cubes and link these together to create intricate structures.[107] With a focus on fun and creativity, MoMath's Family Fridays use art as a way for families to explore math concepts.

**Evaluation and Criticism of MoMath**

This author enjoyed MoMath. The exhibits were interesting and the kiosks by the exhibits were very informative. In terms of integrating art and math, the museum did a great job in a very subtle way. At "PolyPaint," you learn about symmetry through digitally painting. "Bead Geometry" allowed families a chance to build and explore cubes in a hands-on manner. This subtle integration is very effective. Parents are taking their children to have fun while learning about math and one of the ways MoMath creates this fun atmosphere is through art.

Educators seem to enjoy the concept of math in action in science centers such as MoMath but recognize that it has limitations without proper planning and collaboration.[108] The same can be said for casual visitors. Ed Rodley, author of a museum blog "Thinking

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[106] Observation of "Bead Geometry", November 7, 2014

[107] "Family Friday: Crowd Sourcing Origami" Museum of Mathematics, accessed October 18, 2014, https://in.momath.org/civicrm/event/info?reset=1&id=241

[108] Caralee Adams, "Museums Opens doors to informal math learning," Education Week, June 19, 2013, accessed November 7, 2014, http://www.edweek.org/ew/articles/2013/06/05/33mathmuseum_ep.h32.html

About Museums: Thoughts on museums, content, design, and why they matter", gives MoMath,"some mad props for trying to tackle mathematics in an interactive science center format. They do a great job of portraying mathematics as colorful, surprising, and capable of both producing beautiful results and having a deeply beautiful order."[109] One complaint he voiced was that the interpretive content is at kiosks that are not right next to the exhibits (there is generally one kiosk for two exhibits, placed in between the two).[110]

Overall, in terms of arts integration, MoMath is doing a superb job. Math is not just facts and numbers, it is colorful and beautiful. As the only math-based museum in the United States, MoMath has no model to duplicate or look to in the process of creating their exhibits. Despite this, this museum has done an excellent job with the mathematical subject material and in using this material to create exhibits that very often integrate other disciplines, notably, the arts.

[109] Ed Rodley, "Review: The National Museum of Mathematics (MoMath) in New York City," Thinking about Museums, January 4, 2013, accessed November 6, 2014, http://exhibitdev.wordpress.com/2013/01/04/momath-review/
[110] Ibid.

# Chapter 5

## Case Study: The Kennedy Center for the Performing Arts

### Introduction

Having previously looked at art museums and a math museum, this case study features another type of cultural institution, a performing arts center, and its efforts at arts integration. The Kennedy Center for the Performing Arts is located in Washington, D.C. It is considered to be the center of the performing arts in the United States. Its mission states:

> The Kennedy Center is committed to increasing opportunities for all people to participate in and understand the arts. To fulfill that mission, the Center strives to commission, produce, and present performances reflecting the highest standards of excellence and diversity indicative of the world in which we live, and to make those performances accessible to the broadest possible audience through arts education.[111]

In order to fulfill this mission and to reach the broadest possible audience for the arts, the Kennedy Center created *ArtsEdge* in 1996 and Changing Education Through the Arts in 1999.[112] *ArtsEdge* successfully integrates the arts and sciences into a cohesive curriculum, providing a model for institutions that wish to pursue arts integration education. This education is focused on the integration of the arts and sciences, without giving preference to either discipline. The staff of the Kennedy Center has developed lessons and professional programming to aid teachers to integrate the arts into science teaching to allow for greater student engagement. The resulting product is *ArtsEdge's* arts integration curriculum.

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[111] "Kennedy Center: Education Program Mission Statement." Kennedy Center. Accessed October 25, 2014. http://www.kennedy-center.org/education/mission.html.

[112] "ARTSEDGE: Welcome!" The Kennedy Center: ARTSEDGE - the National Arts and Education Network. Accessed October 24, 2014. http://artsedge.kennedy-center.org/about.

These lessons serve as an exemplary case study of integrated arts education for many reasons. First, the lessons reach beyond the visual arts into music, dance and theater. Second, *ArtsEdge* places a lot of emphasis on training the educator first. It encourages educators to review current research and emerging issues in arts learning to support innovative arts teaching.[113] And perhaps because of this, schools utilizing this program give extremely positive feedback. Next, the program reaches into schools, communities, and families by providing these groups with printed materials, on-line resources and classroom support services. Finally, *ArtsEdge* incorporates lessons designed for varying grade levels and provides programming to meet national and state standards for both arts and sciences.

The educators at the Kennedy Center write that the two most important reasons for engaging in arts integration are, "1. Arts integration practices are aligned with how students learn and 2. Arts integration energizes teachers by providing increased professional satisfaction."[114] Research done by the program designers of *ArtsEdge* found that art integrated learning provides a more creative, active, and experimental learning style that teaches students about problem solving and also makes learning more relevant to real world situations. Their research has also shown that teachers who participate in arts integration programs feel more excited about teaching and feel that arts integration improves student learning,[115]

This case study will focus on the Changing Education Through the Arts partnership and review one lesson offered by the Kennedy Center.

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[113] "ARTSEDGE: Welcome!" The Kennedy Center: ARTSEDGE

[114] Lynne Silverstein and Sean Layne, "Two Big Reasons," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/arts-integration/why-arts-integration/why-two-big-reasons

[115] Ibid.

**Case Study**

The *ArtsEdge* curriculum is the result of an effort that started in 1996 and was aimed at clarifying arts integration principles and identifying practices that would have maximum impact.[116] *ArtsEdge* defines its arts integration curriculum as "an approach to teaching in which students construct and demonstrate understanding through art form. Students engage in a creative process which connects an art form and another subject area and meets evolving objectives in both."[117] Using this curriculum, the Kennedy Center partnered with local schools that were focused on the arts and arts integration creating a program called Changing Education Through the Arts (CETA). It was through this partnership that the Kennedy Center's staff realized that the degree to which the arts were successfully integrated depended on the teacher. CETA's programming had not prepared the teachers enough for the actual implementation of the lessons.[118] The Kennedy Center's educators and its partner schools went back and began to do more research.

The first aim of *ArtsEdge* was to clarify what arts integration actually meant. By looking at other institutions that utilized arts education, they found that there were three types of art education. The first was "Art as Curriculum", meaning that there is a music teacher, a visual arts teacher, and a drama teacher who each focus on that specific discipline. The second is "Arts-Enhanced Learning". In this model, art is used to enhance other subjects. The example given is that students learn the ABCs to a song without discussing melody. Art is seen as a hook to bringing students into the content. The third

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[116] Lynne Silverstein. "ARTSEDGE: CETA Background." The Kennedy Center: ARTSEDGE - the National Arts and Education Network. Accessed October 24, 2014. http://artsedge.kennedy-center.org/educators/how-to/arts-integration/changing-education-through-the-arts/background.

[117] Lynne Silverstein and Sean Layne, "What is Arts Integration: Background," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/arts-integration/what-is-arts-integration

[118] Ibid.

type of arts learning they identified is "Arts-Integrated Learning". In arts-integrated learning there are learning objectives from both the art disciplines and another curriculum field. Teachers introduce their students to exploring the connections between art and another discipline.[119]

When developing its arts integrated curriculum, the Kennedy Center's staff also looked to gain an understanding of the place arts integration held in the history and theory of education. It first looked at progressive education theories and the work of John Dewey, Lev Vygotsky and Jean Piaget. Dewey believed that students should have to think during the learning process; this happened by doing activities that related to the material. Vygotsky believed that learning was a social process. Piaget wrote that learning was developed within a person through their play and experiences. These educators were the first to understand that education was more than memorization. The staff also looked at Sir Ken Robinson's *Out of Our Minds: Learning to be Creative*, a book that focuses on the skills needed by the 21st century workforce. These skills include imagination, flexibility, collaborative thinking skills, and the ability to work well in a team.[120] And they consulted *How the Brain Learns* by David Sousa, an educational theorist, who wrote that "educational researchers and cognitive scientists believe there are ideal conditions for learning and remarkably, arts integration generates these conditions."[121] By studying these educational theorists, *ArtsEdge* and CETA got a better understanding of where arts integration fits within the scope of education history and how it is grounded in educational theory.

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[119] Silverstein and Sean Layne, "What is Arts Integration: Background."
[120] Lynne Silverstein and Sean Layne, "Public Education in the United States, Setting a Context for Arts Integration," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/arts-integration/what-is-arts-integration#historical-context
[121] Ibid.

Not only is *ArtsEdge* grounded in the history and theory of education, it is very accessible to teachers. One aspect of this curriculum that is very helpful to teachers is a checklist that ensures that a teacher is actually integrating the arts into another curriculum, not just enhancing the lessons with art. The checklist notably reminds teachers to use constructivist principles, like experimentation, collaboration, and problem solving, and to have the students demonstrate their knowledge though art. It also asks if art is connected to another aspect of this curriculum.[122] As seen in other examples, a problem with arts integration curricula is that some teachers don't utilize them effectively. This checklist is meant to ensure that teachers can properly direct their classroom.

*ArtsEdge* is located in an open-access web portal that allows educators to explore variations of arts integration into different subject areas. Teachers select a grade level (K-12). Then they select the type of art they want to integrate, choosing between dance, literacy arts, media arts, music, theater and visual arts. This curriculum is unique because it focuses on more than just the visual arts, one of the reasons why this is an important model for arts integration. The teacher's then can choose "other subject" – the subject for the integration. The choices here are English, geography, history, informal education, language arts, math, physical education, science, social studies, technology, and world languages.[123] This "lesson finder" makes it easy for teachers to search for lessons that relate to their subject.

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[122] Lynne Silverstein and Sean Layne, "*What is Arts Integration? : Checklist*" The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/arts-integration/what-is-arts-integration#arts-integration-checklist

[123] "Lesson Finder," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/lessons

*ArtsEdge* is designed to appeal to the learning styles of many different students. Each lesson has a different activity associated with it. In a lesson about animal habitats, teachers are given the names of different books to read to introduce the topic.[124] The teacher can select the book that best fits their students' learning style. In a lesson about the water cycle, one component is a demonstration to show the water cycle in action (thus a good interactive lesson for visual learners). The lesson begins with the teacher boiling water. When the steam starts to rise off the water, the teacher will place a container filled with ice over the steam. This will cause condensation to occur along the bottom of the container. This condensation will start to drip making it rain. Art is integrated in this lesson through music as the children are taught chants and songs related to rain and there is also an activity to make a musical instrument (a rainstick). In a lesson about Alexander Calder, a sculptor who invented the mobile, teachers are supplied with a worksheet to be completed by students after they have created their own mobile. As part of this project, students learn about three different types of levers and the physics of mobiles such as potential and kinetic energy, balance, force and load. This worksheet asks the students to reflect on what they have learned through this process, creating a lesson perfect for logical-mathematical learners.[125] By taking into account students with different learning styles, this curriculum is able to engage a wider audience.

Each lesson includes images the teachers can use while teaching. Due to the fact that all of the information is on the website for *ArtsEdge*, teacher can hook up their computers

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[124] Diane Ambur and Carol Parenzan Smalley, "Animal Habitats," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/lessons/grade-k-2/Animal_Habitats

[125] Eileen Ewald and Jill Gerlman, "Alexander Calder: Master of Balance," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/lessons/grade-5/Alexander_Calder_Master_of_Balance

to a projector and immediately be ready to start class. If their school does not have this technology, the educator can print out these images. Each lesson also contains background information for the teacher to explore and additional resources for the students to continue learning. Another outstanding aspect of these lessons is that most of them offer an assessment for the teachers to test how much their students have learned. Each lesson is connected to the National Standards for the Arts and the National Standards for the companion subject, as well as to individual state standards.

The Kennedy Center has a partnership with local schools called Changing Education Through the Arts (CETA). This partnership began in 1999, after the *ArtsEdge* curriculum was created. As noted earlier, this partnership initially highlighted flaws in the implementation of the arts integration curriculum. As a result, the Kennedy Center revamped this program and produced the present day goal for CETA:

> Examine how a sustained professional learning program in arts integration based on national, state, and local standards and best practices in professional learning could yield changes across an entire school in the way teachers teach and the way students learn. The program also set out to examine how collaborative professional learning models in arts integration would affect the school culture—moving teachers away from isolation and toward an interactive and supportive community of learners.[126]

CETA wants to teach educators how to plan and implement arts integration and to create a culture in the schools that allows for continued teacher learning and collaboration. In 2011, this partnership extended to sixteen schools in Virginia, Maryland and the District of

[126] Silverstein. "ARTSEDGE: CETA Background."

Columbia, and to 400 teachers.[127] This partnership has lofty goals and the high number educators involved in it prove that this program is working for both students and teachers.

CETA is focused on professional development. It offers workshops and courses at the Kennedy Center and nationwide and also has lessons available on DVD's. It organizes a yearly conference that trains educators in arts integration.[128] The goal of this training is to allow educators to confidently implement the arts integration material and successfully complete the checklist for each lesson they use.

There are five key features of CETA. They are:

1. Shared Definition of Arts Integration
2. Whole School Implementation
3. Professional Learning with Emphasis on Classroom Implementation
4. Partnership Between an Arts Organization and School/School District
5. Ongoing Assessment and Evaluation for Continuous Program Development.[129]

**Evaluation and Criticism of *ArtsEdge's* Arts integration Curriculum**

Evaluation is a key feature of the CETA partnership and to meet this goal an evaluation of the CETA program was conducted during the 2012-2013 school year in thirty-two schools in the Washington D.C. metropolitan area. It focused on fourth and fifth grade students, parents and teachers. 796 students and 90 teachers were evaluated in this survey. The study compared CETA participating schools to those in a control group outside

[127] Lynne Silverstein. "ARTSEDGE: CETA Background."
[128] "Arts Integration Resources," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/series/arts-integration/arts-integration-resources
[129] Lynne Silverstein, "Key Features," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/how-to/arts-integration/changing-education-through-the-arts/key-features

of the CETA program. The evaluation was conducted to find how creativity and student engagement were impacted by the CETA program. To gauge this, the evaluators went back to the classrooms three times during the year.[130]

To measure students' creativity, the evaluators looked at three aspects of ideation behavior: fluency, flexibility and originality.[131] Compared to the non-CETA Schools, the CETA students demonstrated 2.4 percent more ideation behavior, which indicates that CETA students were producing more original and creative ideas.[132] CETA students also demonstrated a more positive attitude about the arts, with 2.8 percent higher scores in this category. Students also stated that they believed that the arts included science, history and math. The survey concluded that the results show that the students in the CETA schools believe that the arts can inform the non-art disciplines.[133] When specifically focusing on the CETA students, the evaluation found that over the course of the school year these students demonstrated an increasingly positive attitude toward the arts. They were also more flexible and creative. 2.6 percent of students had an increased positive attitude about the arts and a 2.8 percent increase in attitudes about flexibility (referring to the ability to shift categories comfortably and quickly, an important component of creativity).[134] They also, remarkably, showed a four percent increase in the use of creativity in deciding the value of an idea, meaning that they were better able to use original thinking in making

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[130] Chand O'Neal, "Selected Findings from the John F. Kennedy Center's Arts in Education Research Study: An Impact Evaluation of Arts-Integrated Instruction through the Changing Education through the Arts (CETA) Program". The Kennedy Center: ArtsEdge (2014) assesses October 24, 2014. http://artsedge.kennedy-center.org/~/media/ArtsEdge/LessonPrintables/articles/arts-integration/KC-AE-Selected_Findings_CETA.pdf, 1

[131] Mark A., Runco, Jonathan A. Plucker, and Woong Lim. "Development and Psychometric Integrity Of A Measure Of Ideational Behavior." *Creativity Research Journal* 13, no. 3 and 4 (2001): 393-400.

[132] O'Neal, "Selected Findings from the John F. Kennedy Center's Arts in Education Research Study", 5

[133] Ibid, 6.

[134] Ibid, 2.

determinations thus demonstrating an overall increase in critical thinking skills.[135] CETA students also demonstrated a higher level of student engagement at the beginning and end of the school year compared to non-CETA students.[136] Students were also emotionally engaged about 2.8 percent more in CETA schools.[137]

Teachers were also asked about the CETA partnership. Their evaluations were completed using two classic assessment batteries, the Teachers' Evaluation of Students' Creativity (TESC), and the Runco Ideational Behavioral Scale – Teachers (RIBS-T).[138] They reported that their students' creativity increased throughout the school year by about two percent. However, the non-CETA teachers' rating of their students' creativity stayed consistent for the whole year. Social creativity - teamwork and collaboration - also increased throughout the year in CETA schools while non-CETA schools demonstrated a consistent score throughout the year.[139] The survey of the teachers showed that students were not only more engaged, they enjoyed school and participated in class. [140]

Parents were the third group surveyed about arts integration in this evaluation. Parents reported increased creative behavior, like risk taking and flexibility of thought, in their children from the beginning of the school year to the end of the school year in the CETA school. Non-CETA schools did not demonstrate this change. The parent's aspect of this evaluation found that CETA children attended more art-related activities that non-CETA schools. These activities included a wide range of activities like outside of school arts

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[135] O'Neal, "Selected Findings from the John F. Kennedy Center's Arts in Education Research Study, 10
[136] Ibid, 13
[137] Ibid, 14
[138] "Application for Grants Under the Arts in Education National Program," *U.S. Department of Education* , (July 2012) accessed November 20, 2014, http://www2.ed.gov/programs/artsnational/kennedyapp.pdf, Pg. 215
[139] O'Neal, "Selected Findings from the John F. Kennedy Center's Arts in Education Research Study," 7
[140] Ibid, 16.

events, ceramic classes, and even participating in discussions about artistic issues.[141]

The results show the arts integration is effectively helping students become more flexible and creative. This flexibility and creativity has extended beyond the arts into other curricular areas. For example, more flexible students can look at a math equation and see many different ways to solve it.[142] The evaluation was important not only because it showed the impact of arts integration, but also because it compared CETA to non-CETA classrooms. This comparison allows the results to be used by educators across the country as a way to demonstrate how arts integration can help students learn and to be engaged in school.

Teachers often speak glowingly of the Kennedy's Center arts integration curriculum. Malenia Carney, a teacher in this program, says that because of this curriculum, her students think about science differently. They actually remember information from year to year through this program. She believes this is because students take a more active role in their education. Another educator, Elena Duarte says this program is good for students and the teachers. It allows the teachers to grow and refine their teaching. All students are engaged now and because the lessons take into account the variety of ways people learn, the students are now more equal, says Betsey Walter, a teacher in a CETA school.[143] Having a curriculum that teachers like using and that allows them to see its impact on students goes a long way to provide students with the best education possible. Teachers who feel confident in their abilities will create better opportunities for students to do the same.

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[141] O'Neal, "Selected Findings from the John F. Kennedy Center's Arts in Education Research Study," 7

[142] Ibid, 19

[143] Lynne B. Silverstein, "Perspectives," Kennedy Center: ArtsEdge, accessed November 20, 2014. http://artsedge.kennedy-center.org/educators/how-to/arts-integration/why-arts-integration/why-perspectives

**Lesson Review: Brass Instruments and Pitch**

Beyond the professional development offered to the teachers, *ArtsEdge* offers lessons, at no cost to the user, online. One of these lessons will be evaluated below. For this evaluation, a lesson called "Brass Instruments and Pitch" for kindergarten through fourth graders was chosen in order to show how a different form of the arts could be utilized to each the STEM disciplines. Students will be learning about brass instruments and how they make sounds while using the scientific method.[144]

Depending on the background knowledge of the class, the teacher will review or introduce the brass instruments and the sounds these instruments make. While doing this, they will compare the different instruments based on appearance and sound. After this observation, the teacher will teach them about the scientific process and what a hypothesis is. The experiment for this particular lesson is focused on the trombone. Students will test out different lengths to determine how it affects sound. Students will individually develop a hypothesis for the question, "How does the length of the tubes or crooks of a brass instrument determine the pitch?" Using this hypothesis, students will make a prediction using the format. "If our hypothesis is true, then the pitch created should be higher /lower when the air column is longer /shorter."[145] At this point, students will divide into groups of four. Each student will have a different role: Group leader, recorder, equipment adjuster, and tester. Student will begin testing. One student will play the instrument, gradually changing the length to record the different levels of pitch. Using these results the students will analyze the information as a group and write a conclusion individually. They will take

[144] Rebecca Haden and Leslie Thomas, "Brass Instruments and Pitch," The Kennedy Center: ArtsEdge accessed October 24, 2014, http://artsedge.kennedy-center.org/educators/lessons/grade-3-4/Brass_Instruments_and_Pitch

[145] Ibid.

the information gained in this process and apply it to the making of their own instrument, another group activity. They will do this with a funnel, which will act as a horn, a garden hose or tubing, tape, ruler, and a brass mouthpiece. Using the information gained, the teacher will then lead a class conversation about the difference between pitch, frequency, hertz, and the length of the air column. This type of scientific study is known as acoustics.[146] Students are learning about the science, acoustics, through the arts, music.

"Brass Instruments and Pitch" meets National Standards in the arts, and sciences. For art, students are meeting Music Standard 6, "Listening to, analyzing, and describing music" and Music Standard 8 "Cooperative Learning Understanding relationships between music, the other arts, and disciplines outside the arts". For the science standards, it meets Standard 9, "Understands the sources and properties of energy", Standard 11, "Understands the nature of scientific knowledge", and Standard 12 "Understands the nature of scientific inquiry". The lesson also meets the National Language Arts Standards 4 and 8: "Gathers and uses information for research purposes" and "Uses viewing skills and strategies to understand and interpret visual media."[147]

**Lesson Summary**

The strength of this lesson resides in the clever combination of music and science education. The goal of *ArtsEdge* is to integrate subject areas. This lesson does this very well. The experiment not only allows the students a chance to experience playing the trombone, but also to use the scientific method and to formulate a hypothesis.

By doing the experiment before the discussion of the material, students are able to showcase the knowledge they gained. This allows the children to feel empowered because

[146] Rebecca Haden and Leslie Thomas, "Brass Instruments and Pitch,"
[147] Ibid.

they are taking an active role in their learning. As seen above, this active role is highlighted by the teachers in the CETA schools as one of the reasons they enjoy using the arts integration method of teaching. By gaining and applying information teachers discovered that students remember the lesson better.

One of the skills most focused on in the development and implementation of arts integration is collaboration and teamwork, which is seen in this lesson. The students work together to complete the experiment. However, this author thinks that this could be pursued more. For example, the students could work collaboratively to formulate their hypothesis and predictions.

**Case Study Conclusion**

*ArtsEdge* provides a great model for integrating the arts and other disciplines. Earlier, this paper reviewed arts integrations efforts at the Getty Museum and at the National Museum of Math. These institutions have innovative ideas and provide great resources to teachers. The arts integration program offered by *ArtsEdge* at the Kennedy Center is more comprehensive than those programs as it extends arts integration to music, drama and dance. The program has a very thoughtful curriculum and, perhaps most importantly, makes a serious effort to educate the educator first. This gives an added boost of confidence to teachers and this is integral to the success of presenting the lessons. Another plus to this programming is that true integration is considered in each lesson. For example, in the music lesson reviewed above, the lesson truly allows the two subjects – art and science - to be integrated. Students are not just playing music as an aside or as a simple play activity; the playing of the instrument serves a purpose to the lesson and to the experiment. Finally, as seen in previous case studies in this paper, the important criteria of

curricula designed for each grade level and adherence to both National and State Standards, are met in *ArtsEdge*'s arts integration program. Its open access also makes this program stand out: it makes it accessible to any school that is looking to consider arts integration programming for their students.

# Chapter 6

## Case Study: The Walters Art Museum

### Introduction

This case study will look at the way in which The Walters Art Museum in Baltimore, MD, puts into practice its commitment to reaching people of all backgrounds through its educational programming, including its virtual school curriculum *Integrating the Arts.*

The Walters Art Museum houses the vast and eclectic collections of William T. and his son Henry Walters. The museum is known around the world for the breadth and quality of its holdings. According to its mission statement,

> The Walters Art Museum brings art and people together for enjoyment, discovery, and learning. We strive to create a place where people of every background can be touched by art. We are committed to exhibitions and programs that will strengthen and sustain our community.[148]

*Integrating the Arts* is an online resource designed for teachers who want to integrate the arts into their subject area or, vice versa, other subject areas into art classes. The resource includes printable activity booklets for the teachers and interactive flash games that can be played by the students. The lessons are designed to meet the Maryland curriculum standards.[149]

The Walters Art Museum was chosen as a case study for many reasons. First, its arts integration programs are intimately connected to the museum's collections and thus gives access to these objects to students who otherwise might not have the opportunity to learn

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[148] "Mission Statement," The Walters Art Museum, accessed November 4, 2014, http://thewalters.org/about/mission.aspx

[149] "Integrating the Arts," The Walters Art Museum, accessed November 4, 2014, http://thewalters.org/integrating-the-arts/

about them. Also, while the program is geared to middle school students, it is flexible enough to be adapted to any grade level. The *Integrating the Arts* format is attractive to students as it offers an online interactive component to use in the classroom.

**Case Study**

The Walters Art Gallery (later Walters Art Museum) opened to the public in 1934 as a result from the generosity of Henry Walters, who bequeathed an extensive and varied collection of over 22,000 items collected by himself and his father, William Walters, to the city of Baltimore. The bequest was earmarked "for the benefit of the public". The Walters boasts that its collection is "a one of- a-kind survey of fifty-five centuries of art."[150] The civic mindedness that inspired this museum continues today at The Walters through its many education programs including its *Integrating the Arts* curriculum.

The Walters' *Integrating the Arts* debuted in November of 2006.[151] During an interview conducted by the author with Amanda Kodeck, Head of School and Docent Programs at The Walters, Kodeck responded to several questions about the conception and development of the program and the impact of arts integration initiatives such as STEAM. She said that, "While the STEAM initiatives did not directly influence the development of *Integrating the Arts*, we [The Walters] did use a lot of science components. STEAM wasn't really as strong in the school system when we developed the site as it is now."[152] When asked if the museum saw a need for this type of programming in the schools or if teachers in the community had requested it specifically, Kodeck said, "We [The Walters] consider

[150] "The History of the Walters Art Museum, " The Walters Art Museum, accessed November 4, 2014, http://thewalters.org/about/history/

[151] Scott Sayre and Jacqueline Copeland, "Using Pachyderm to Design an Educational Web Resource for K-12 Teachers and Students", accessed November 20, 2014, http://www.archimuse.com/mw2007/abstracts/prg_325001083.html

[152] Amanda Kodeck, Interview by Author, November 1, 2014. (All quotes from Kodeck are from same interview)

ourselves a leader in arts integration for museum programming so we felt it was a natural tie to create an arts integrated website. We both [The Walters and the local teachers] saw the need but, also got many requests from teachers." Kodeck said that integrating the arts into the other subjects was a "natural connection, one that we do with a lot of our programming."

The Walters developed its *Integrating the Arts* curriculum in five stages, according to Kodeck. They began with the Medieval section, then moved to Ancient and then on to the Renaissance. The Chinese and Islamic sections were added later to round out the curriculum. The Walters used grant funding in developing its programs and these grants determined the order of the lesson's development. Kodeck shared that each section of its programming had a similar inception, "First, museum staff brainstormed the best objects and curriculum connections as well as activities. They were then developed and then vetted with teacher advisory groups. Teachers gave feedback throughout the entire process. Once the sites were developed, we did test groups and made changes based on teacher feedback." Having teacher feedback at every step of the development process led to an online resource that is actually useful for teachers. The teachers led the Walters to the lessons they wanted and needed.

**Evaluation and Criticism of *Integrating the Arts***

The Walters Art Museum also uses *Integrating the Arts* in its professional development programs. Kodeck stated, "We use the site a lot for professional development workshops and teacher trainings. We have developed many workshops around the site. Teachers love to see the variety in how they can use the arts and technology and arts integration." As seen in *ArtsEdge* at the Kennedy Center, teachers are interested in ways

they can learn about how the arts can be fused into the other disciplines. *Integrating the Arts* is to be used by teachers in their classrooms or as homework for their students.[153] The art focus of the program is on visual or fine arts.

According to Kodeck, there is generally very positive feedback to the Walters arts integration website. The teachers who use the site have told Kodeck that they "love it". However, there are problems with accessibility. Some teachers say that the site is hard to navigate. It is also not available on all computer formats, specifically not on HTML 5.[154] Using this site, this author experienced some of the navigation concerns mentioned by the teachers, though found them very minor. The website is organized according to the different lessons that can be selected in the *Integrating the Arts* homepage. One confusing aspect is that the Ancient, Medieval and Renaissance lessons are under one category heading, "Mummies, Manuscripts and Madonnas". Combining these three makes them difficult to find, especially since Islamic Art and Chinese Art have their own separate sections. Beyond this beginning section, the website makes much more sense and is easy to navigate.

Another criticism is that while the *Integrating the Arts* website states the lessons meet Maryland State Standards, the website does not specifically state which standards are met and at what grade level. Perhaps for educators working with the site and having further interaction with the Walters as a teaching resource, the standards are better described and articulated, perhaps they are even intuitive. But for a casual observer of this website such as this author, it left a hole. For educators outside the state of Maryland

[153] "Integrating the Arts," The Walters Art Museum,
[154] Kodeck, Interview, November 2014

looking to the Walters as a resource, it could be difficult to translate the intended standards to those of their home state.

**Lesson Review 1: Integrating the Arts - Islam[155]**

The Islamic Arts section of *Integrating the Arts* allows the educator to choose from math, science, social studies and language arts as companion subjects. Each subject has lessons associated with it. Here I will focus on one of the lessons in the science section, Glass Beakers, to continue looking at how museums can integrate the arts into science and math. This lesson was chosen because it shows the science of conservation in a way that allows kids to experiment. It was also chosen because of what it is missing. The teachers are not given ideas for how to convey the information they are given to their students, i.e., there is not a specific lesson plan laid out. This lesson focuses on two glass beakers from the Walters collection. They are Syrian in origin, from about 1260. The cylindrical beakers are decorated with haloed figurines and buildings. The lesson starts with a discussion of the techniques used by the artist. The maker of these glass beakers used an enameling technique. This technique involved painting the design on the finished beaker using crushed, colored glass and then re-heating to fuse the materials.

The next area of the lesson looks at the design of one of the beakers. This is where the teacher can discuss the artistic merits of the work and the story the artist was attempting to tell. The beaker shows a man riding a donkey. During this time in the Middle East, many communities were Christian and it is thought that this man is Christ riding into Jerusalem. Another important aspect of this section is that it shows the beaker in a video which allows the viewer to see it from all sides.

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[155] "Integrating the Arts: Islam," The Walters Art Museum, accessed November 4, 2014, http://thewalters.org/integrating-the-arts/islam/

The last section of the lesson focuses on conservation and refraction. It explains that this glass that is over 700 years old and will need to be fixed. Conservators are the people who repair and preserve works of art. The lesson asks the question, "how do they determine which material is best [for the repair of the glass beaker]."[156] The lesson begins the process of answering this question by discussing refracted light. When light travels through glass, it is bent. This bend in the light can be measured. In order to find a material to repair the glass of the beaker, a conservator must test out different substances to see if the angle of refraction is similar to that of glass. Next comes the interactive flash activity for this lesson. The user clicks on a "laser pointer" that is shone through a piece of glass. This allows the user to discover the base angle. This is the angle at which light goes through the glass beakers. The user then shines the laser through four different materials: diamond, wax, casting resin and leaded glass. Measuring the angles of light refraction through each material will allow the user to see which one will maintain the glass beaker's appearance. Using this information, the user selects the material they would use to repair the beakers. The user should have found that the casting resin is the material with the angle of refraction that is closest to that of the glass of the beaker. Once they have selected this answer, the interactive shows them the repaired glass beaker. When repaired, the design is much easier to see.

One strength of this lesson is the interactive component. As seen above, it allows the participants to experiment with refraction. It also makes them apply what they have discovered to the question 'what material should be used?'. The students are discovering

[156] "Integrating the Arts: Islam," The Walters Art Museum

the information without being told. Another strength is that art and science are discussed with the same object.

While the interactive component is a great aspect of this lesson, it is not perfect. A weakness of this lesson is that beyond the interactive, there are no questions for the teacher to ask. They are given background information on the technique and the design but not on how to teach the lesson. To make a great lesson, this would be necessary. In order to discuss the design, teachers could ask the students what they see, whom they think the man is, and what colors are used. This would allow the students to really look at what they are seeing. This is an especially notable missing piece of this lesson as it is meant for both art and science teachers. Science teachers will not have training in teaching about art. Without some plan for them to follow about how to teach about art objects, the teachers will not be able to convey to the students a full understanding of the artwork.

**Lesson Review 2: Integrating the Arts -China[157]**

The second lesson to be reviewed here is the math-based lesson in the Chinese art section of *Integrating the Arts.* This lesson looks at a handscroll called "Free Spirit Among Stream and Mountains". The first section of this lesson focuses on what a handscroll is and how it is different from other types of art. It cannot be hung on a wall like a photograph or a painting; the only way it can be viewed is by unrolling it with your hands. As the scroll is longer than a person's arm span, the viewer will find it difficult to see the entire scroll at once. Thus one of the great positives of this type of art is that it is best experienced through interaction, "A Handscroll offers a dynamic and interactive experience, putting you in direct

[157] "Integrating the Arts: China," The Walters Art Museum, accessed November 4, 2014, http://thewalters.org/integrating-the-arts/china/

contact with the art."[158] This section comes with a video that allows the eye to slowly move along the handscroll one small section at a time allowing a virtual interaction with the artwork.

This lesson's second section is about Chinese use of perspective. Chinese landscape painting has a shifting point of view due to the fact that the whole scroll cannot be seen at once. It is meant to make the viewer feel as if they are wandering through the landscape. The lesson states that, "Real art, according to Chinese Tradition, transforms feeling and mood into a visual narrative; it does not try to become an imitation of the world we see."[159] Chinese landscape painting shows the whole scene, as if the viewer is actually in the picture.

The third section focuses on the math of shipping objects. It discusses how objects need to be protected when they go outside of the museum, just like people do when they go outside into the cold. This lesson has three objectives:

1. Describe how and why art is crated for protection during travel.
2. Calculate and express dimensions based on given measurements.
3. Create a graphic emblem that is symbolic of a group of objects.[160]

The lesson first directs teachers and students to an article from the Field Museum in Chicago about the packing of objects for an exhibition in Mexico. This article includes pictures of the packing of these objects. Then the students are asked to complete a worksheet (provided on the website) to determine the size of crates needed for certain objects. The worksheet has pictures of four objects and their measurements. To determine

[158] "Integrating the Arts: China," The Walters Art Museum
[159] Ibid.
[160] Ibid.

the size of create needed, the students need to add six inches to the height of the object and two inches to the front, back and both sides of the object. The students will do this math and place their answers in the designated column on the worksheet. This helps students to understand dimensions and can be used as part of a unit on measurement or geometry. The last part of this section has the students draw an emblem that would be placed on the crate

The last section of this lesson focused on the conservation of works of art on paper, such as this handscroll. It does this through an interactive called “Fighting Fade: Light Sensitivity testing in museums”. Museums must balance the care of the collections with the need for education and display. This interactive discusses the role of a Blue Wool Card Test. This is a card with eight rows of wool with special blue dyes that fade at different rates. It is a way for museum to monitor how much light an object is getting. The handscroll in particular must be taken off display and placed in a dark, temperature and humidity controlled room when the wool fades to the third row of wool. The interactive for this section is a simulated Blue Wool Card. The first round of tests for this simulation uses three lights. This simulation is meant to show the fade of the blue wool card after twelve weeks of the three lights. After each week, the student records the strip of wool that has faded on the graph seen in the interactive. Once the student has done this for all twelve weeks, the interactive asks. “Can you display the scroll with three lights on for twelve weeks?”[161] Knowing that this art work must be taken off display once the third strip fades and the information discovered through the observation of the Blue Wool Card that at twelve weeks the wool card is faded to the seventh strip, the student will hopefully answer “No” to this question. After this, the students are asked to run the test again, only this time the

[161] "Integrating the Arts: China," The Walters Art Museum

simulation has two lights. After the test, the students are asked, "Can you display the scroll with two lights on for twelve weeks?"[162] The answer to this question is yes.

The math element in this interactive is the graphing. With each week of the simulation students are asked to graph which is the highest strip that is faded and this graphing is repeated for both light simulations. When completed, the students have produced two line graphs, allowing the two simulations to be compared simultaneously.

One factor that makes this lesson a good model is the interactive component. It offers the teachers and students a chance to apply the knowledge they have learned, especially in regards to the Blue Wool Card. The simulation shows the change the light causes over time and the students must graph this information. They then use the graph they created to answer questions about the conservation of the art. Beyond applying information they have gained, this simulation is important because it introduces these Blue Wool Cards in an inexpensive way. Of course, in the perfect world, a class would have access to these materials and do the tests in person. However, due to the expense and time related to this test, many schools are not able to provide these hands on materials and tests. *Integrating the Arts* offers the Walters Museum's resources in a cost effective manner for school. The simulation is also a significantly faster process. In real life, this Blue Wool Card test would take twelve weeks. Focusing on one activity of twelve weeks is very time consuming, especially when teachers are balancing many different units of study, preparing their students for examination, and often, many classes. The simulation offered by *Integrating the Arts* allows this process to be completed in one class period.

[162] "Integrating the Arts: China," The Walters Art Museum

The worksheet related to the shipping of objects is also a strength of this lesson. It allows students to understand the needs of the artwork and apply math to a real work scenario. It is also a ready-made aspect of the lesson for the teachers. However, this could be taken further. Once the worksheet is completed, the teacher could choose one random object from the classroom. The students would measure this themselves and then figure out how big the crate would need to be for this object. Then, instead of just making an emblem, the students could create a box that would fit the object. Using a piece of paper, the students could cut out the area the object would sit in and place this in the box to represent foam used by museums in shipping real articles. On the outside, they could place the emblem they designed earlier. This would not be a functional crate, merely a prototype to allow the students a chance to further apply what they have learned. It would reinforce the information and allow the students a chance understand the work that goes on behind the scenes in a museum.

**Lessons Summary**

Both lessons reviewed above contain interactive components and meet some of the Maryland state school standards. Strengths of both of these lessons are the interactive components that allow students to apply the information they have learned to a real world application, one of the main tenets of STEM education. It is thereby integrating STEM principles with art. However, both lessons lack instructions on how teachers can readily utilize the non-interactive components which could be challenging time-wise for busy teachers. Also, there may be the concern that science and math teachers who use this online resource will not have training on how to teach about art. The same goes for art teachers who want to incorporate the other disciplines into their work. An educator's

comfort with the materials and resources are a critical aspect of arts integration. Without it, the lessons are not quite living up to their potential. The Walters does offer professional development classes to help bridge this gap.

**Case Study Conclusion**

True to its mission statement, The Walters works to strengthen its community by making art accessible to people of every background as demonstrated through development of programs such as *Integrating the Arts*. This program offers an important resource for teachers by using technology and digital elements that can be integrated into their curriculum to bring art and science together. These interactions allow for students to see real world scenarios of science and math in practice in an inexpensive and time effective manner. The lessons also bring art and the collections of the Walters to life for many school children who otherwise might not have exposure to this content. The digital, interactive format is well suited for students who have grown up with technology. Finally, the lessons address Maryland State Standards and are adaptable to various grade levels.

# Chapter 7

## Case Study: Museum of Glass

### Introduction

The Museum of Glass in Tacoma, WA, opened its doors in 2002. It is focused on art glass and glass making, as stated in its mission, "The Museum of Glass provides a dynamic learning environment to appreciate the medium of glass through creative experiences, collections and exhibitions."[163] The original concept for the museum was to honor the work of Tacoma native and world-renowned glass artist Dale Chiluly. At this artist's insistence, the focus was expanded to include glass artists from around the world.[164]

This case study will look at its Science of Art interdisciplinary program. It is noteworthy because it shows how a museum with a singular focus, in this case contemporary glass artists, can effectively practice arts integration in its programming. Like other programs and curricula reviewed in this paper, it addresses learning standards, specifically those of Washington State. What makes this program truly stand out, though, is its combination of outreach with in-museum programming that complements the classroom activities. A requirement of Science of Art is that a museum educator visits the classroom prior to visiting the museum. Teachers are also required to complete an evaluation of the programming once the lesson is complete, allowing the museum to get feedback. Through this, the Museum of Glass hopes to insure that maximum value and impact of its programming.[165]

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[163] "About," Museum of Glass, accessed November 7, 2014, http://museumofglass.org/about
[164] Ibid.
[165] "Science of Art," Museum of Glass, accessed November 7, 2014, http://museumofglass.org/school-programs/science-of-art

**Case Study**

Science of Art was created to provide a new and exciting approach to science and art education at all grade levels. Science of Art is described by the Museum of Glass as "an interdisciplinary program that encourages students to identify the intersection between scientific experimentation and the creative process, and addresses how scientists and artists think alike."[166] The program curriculum is very detailed and meets Washington State learning standards including Next Generation Science Standards.[167] The program's goal is to integrate science and other core subjects with art to enhance learning as the "arts [are] mandatory for students to receive a well-rounded education."[168] Science of Art is designed to reach a variety of learning styles including the kinetic to the aural.[169]

During an interview conducted by this author with Elisabeth Emerson, Education Program Coordinator at the Museum Of Glass, Emerson shared information about the development and conception of the Science of Art program. Emerson said the program was conceived even as the museum was being developed. It was developed throughout 2002 and was rolled out in the schools in 2003.[170] The first step in its development was to go into their community to find out what people needed. The education staff contacted local schools and asked teachers how the museum could best serve them. The answers indicated the museum should attempt to help "art teachers explain science and science teachers explain art."[171] Emerson said, "This program was developed with local educators and was a

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[166] "Science of Art," Museum of Glass
[167] Ibid.
[168] Elisabeth Emerson, Interview with Author, November 12, 2014 (All quotes from Emerson are taken from the same interview)
[169] "Science of Art," Museum of Glass
[170] Emerson, Interview, November 2014
[171] Ibid.

response to their requests and needs of support in the classroom". This feedback resulted directly in the creation of the Science of Art program.

According to Emerson, Science of Art has changed over time. Originally, the program was focused on "creating scientific units based specifically off of current exhibitions and artists in the Hot Shop." However, this created units that were too specific to exhibits and artists and therefore could not be used once the exhibitions changed or when an artist's residency was over. In 2007, the Museum of Glass updated their mission to focus on 'all glass, all the time' in the words of Emerson. In conjunction with this change, Emerson said, "we [the museum staff] also refocused Science of Art, narrowing our units down to The Art of Light and the Art of Color – both of which fit in perfectly with glass artwork." The recognition of the need to change focus speaks well of this program as it shows that the program is not stagnant.

Along with the change in focus of the program, there came a change in the development of the individual lessons. To develop the original sessions, the museum had worked with a college professor. However, this partnership resulted in programs that were not accessible to the students and teachers as the information was too advanced. In order to rectify this problem, the museum worked with the teachers to alter the content so it would conform better to grade level standards.[172] The museum also added new learning components and more activities for students. According to Emerson, "The curriculum is re-mastered every year to apply the ever changing academic standards and also to make it the best it can be." This re-mastering is further influenced by the evaluations completed by the students and teachers.

[172] Emerson, Interview, November 2014

Each Science of Art session follows a strict format. The program begins with an in-class visit by one of the educators from the Glass Museum. This is a 45-minute lesson taught through power point presentations and small group activities.[173] This is one of the characteristics that make this program exemplary. Sending staff to the school allows the students and teachers to start preparing for the actual museum visit. The staff of the museum found that, while the program does include pre-visit lessons that are given to teachers in advance of the museum visit, the teachers often did not have enough time to study and teach this material. They learned from this and changed the program to include the pre-visit.[174] According to Emerson, this change "saw an immediate engagement of students when they arrived at the Museum for their visit and overall better understanding of key learning components." Students now know what to expect when they arrive at the museum and are more familiar with the material being presented during the museum visit.

The museum visit itself is three and a half hours.[175] There are four different parts to the on-site visit, each called experiences. The first one is the Hot Shop. In this space, students can see a live glass blowing demonstration. There is a specific presenter in this section, called an emcee, who will speak to the students about the chemistry of glass and the artists who are making the glass products. Although the emcees are not directly involved with the Science of Art program, they are told when a class is coming in that is taking part in this museum offering. They are trained in the Science of Art material and

[173] Emerson, Interview, November 2014
[174] Ibid.
[175] "Science of Art," Museum of Glass

tailor their presentation to that particular school program.[176] This is an important aspect that allows the program to be cohesive.

The second experience that makes up the Science of Art program is the gallery tour. The gallery tour is co-taught with a docent and art educator. The art educator will be the same staff member who conducted the in-class pre-visit, thus promoting continuity. The glass art that the students will be looking at are pre-chosen based on their relevance to the Science of Art Curriculum.[177] Emerson stated that the program looks at a number of artworks that, "showcase different elements of light and color." In 2013, the gallery tour looked at artworks such as Joseph Rossano's *Mirrored Murrelets* and Ellin Christopher's *Water Splash Coconut.* The discussion based on Rossano's work focused on how the mirrored convex glass changes how a reflection looks. *Water Splash Coconut* includes components that are opaque, translucent, and transparent. The discussion centers on how light reacts to these elements.[178] The docent focuses on the artwork itself and the meaning and interpretation of the object. The art educator discusses the artwork's connection to science.[179] This is an excellent way in which the Museum of Glass demonstrates collaboration to its student visitors.

In order to reinforce the material being presented in Science of Art, the third experience of the in-house visit is the Art Studio. Here, students create their own artwork based on the concepts of color and light that they have learned through the Science of Art lessons.[180] This project changes each year, but it always focus on color and light. In the past,

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[176] Emerson, Interview, November 2014
[177] Ibid.
[178] "Science of Art 2013: Art of Light Gallery Exploration," Museum of Glass (Unpublished Lesson, 2013), accessed November 12, 2014.
[179] Emerson, Interview, November 2014
[180] Ibid.

they have created sun catchers using CDs and glass that has been tumbled to create smooth edges. They have also created a layered collage using tracing paper, colored pencils and magazine images. Emerson said that the students are asked to "demonstrate transparent, opaque and translucency in their image by cutting out some type of hole in the paper and layering magazine images". The project is meant to enforce what the student has learned about light and color.

The fourth experience is the Theater. Here students witness a discussion between an artist and a scientist about how art and science intersect. According to Emerson, this is "a face to face conversation about the importance of understanding how art and science work together." Over the last few years, the museum has worked with a professional neon artist, Galen Turner, for this experience and a scientist who utilizes hands-on activities to enhance the discussion.[181] Emerson said, "At first, this art seems like only whimsical fun, but it also allows students to see first-hand how the artist needs to have a strong science background in order to have his artwork turn out the way he envisions … some of his work also includes mechanics which adds another level of science to the experience."

Science of Art additionally includes post-visit activities that teachers can pursue in their classrooms. Finally, the students are provided with a reflection journal to help them document their learning.[182]

**Evaluation and Criticism of Science of Art**

According to Emerson, Science of Art has been evaluated both "professionally and internally. For the most part, the evaluations are positive but we [the museum staff] do have some difficulties gathering information from students. The students are given a

[181] Emerson, Interview, November 2014
[182] Ibid.

reflection journal on which they begin to work during their in-class lesson and continue to write in while in the different on-site experiences. Students do not always fill out all of the questions and we are usually working with limited evaluation materials." Emerson indicated that she is working with an outside contractor to revise these journals to a simpler double-sided worksheet. This change will focus the journals on the components of the lesson that the museum wants the students to learn. The hope is then that the students will do a better job in evaluating and giving feedback on the Science of Art program. [183] While student feedback is lacking, Emerson said, "Teacher feedback is great. We have many teachers that have brought their students for tours repeatedly though out the years." She also shared this quote from a teacher who completed the evaluation of the program,

> We spent the morning before we visited the museum learning about the chemistry of glass art. Being at the museum and seeing all of the different techniques and artists really brought our learning to life! The students especially enjoyed the hot shop, and we appreciated how wonderful your staff was in answering questions. Our students loved the opportunity to explore such a tangible and creative connection between art and science. We are so lucky to have you as a resource in our community.

As indicated above, student journals are also considered in the evaluation process at the Museum of Glass. These journals are evaluated by the museum staff and given a pass/fail grade based on five objectives: Observe (identifying and recording observations); Apply (the ability to apply scientific principles); Extend (the ability to extend scientific principles to an artistic perspective); Compare (the ability to distinguish between different

[183] Emerson, Interview, November 2014

types of glass); and Communicate (using scientific vocabulary). The evaluation results are divided to assess elementary, middle, and high school student responses. As was mentioned above, the most significant factor in the student evaluations is the lack of participation from the students in the evaluation. While all objectives show significant gains in learning from the pre-to-post visits, oftentimes the sample pool is very limited as so few of the journals are completed enough to be compliant enough for evaluation.[184]

**Lesson Review: The Luminous Optics of Glass [185]**

This review will look at the pre-visit materials given to the teachers by the museum. These are optional and can be completed before or after an educator from the museum visits the classroom. The Luminous Optics of Glass lesson is intended for middle school students but can be adapted to other grade levels as needed. This expanded lesson provides great enrichment to the museum visit. The lesson given to the teachers begins with an introduction to the states of matter (gas, liquid and crystalline) and information about how and why glass has its own peculiar state: it has "the mechanical rigidity of crystals, but the random disordered arrangement of molecules that characterize liquids."[186] Next, students are taught about the components of glass: the former, the flux and the stabilizer. The former is generally silicon dioxide and the flux, which helps the former to melt at lower temperatures, is either soda ash or potash. The stabilizer helps keep the glass from dissolving. Students are taught about materials used to color glass such as iron, copper or cobalt. The lesson then explores the properties of glass, those being that glass is strong, hard, elastic, chemical resistant, thermal shock resistance, heat absorbent, electrical

[184] "Evaluation Round 2" Museum of Glass (Unpublished evaluation) 2014, accessed November 12, 2014,
[185] "Science of Art: Luminous Optics of Glass " Museum of Glass, accessed November 7, 2014
[186] "Ibid.

insulating and that it has optical properties. Students are given real life examples of how glass is used, e.g., headlights, lighting, structural glass and tableware. The lesson then moves on to the principles of light.

The students are taught about what light is and about refraction and reflection and then explore different types of glass lenses. Once this introductory material is shared, students are given several experiments based on glass, light and color. First, students examine color and transparency through the use of colored transparent filters. The experiment is intended to teach them how filters can change the color of light as well as what happens when mixing primary colors. Students first use colored pencils to write and then place the colored filters over the writing to examine how the colors are impacted. The next experiment asks students to explore light reflection using flat and curved mirrors. Student set up their flat mirrors using stands made out of modeling clay and then the room lights are turned off. When light hits a mirror, the beam is reflected off the surface at a different angle. In order to investigate this principle, the students shine a flashlight at their mirror to see at what angle the light bounces off the mirror. Students are encouraged to measures angles of the reflections and to see if they can come up with mirror arrangements that allow the light to bounce off multiple mirrors. Next, the experiment is repeated using curved mirrors. Students are then asked to compare the reflective properties of both types of mirrors.

As discussed above, once the classroom visitation is completed, students go to the Museum of Glass to see the process of glass making and to further explore the principles of light, color and reflection though visits to the HotShop, Exhibition Gallery, the Theater and finally for a hands-on experience in the Studio.

For middle school students, this lesson meets the Next Generation Science standards for science and engineering processes and the standards for the disciplinary core ideas of the structure and properties of matter. The Physical Science standards of Wave Properties are also addressed through the optical study of glass presented in this lesson. For the arts, the lesson meets the standards of responding to an arts presentation including actively engaging and describing experiences. The lesson also is intended to meet the standards of developing personal aesthetic criteria that can be used to communicate artistic choices and also the standard to demonstrate and analyze the connection between art and other content areas.

**Lesson Summary**

The lessons provided to the teachers through "The Luminous of Optics" program successfully integrate art and science. The portion of the lesson about color and light provides information that is fundamental to artists. The portion of the lesson about glass teaches important concepts of physics. The lesson also allows the students to experiment and to tailor the experiments to expand their learning. Overall it provides a very good example for other museums looking to build arts integration programs.

In practice, the Museum of Glass provides outreach programming to teach some portion of the classroom lessons in the schools, which is a great idea for other museums to consider when looking to provide arts integration. This is especially true considering that teachers often do not have time to look at the pre-visit material given to them, making the classroom visit an important part of this program. While obviously not every museum has a working glass studio, the lesson could easily be adapted by using a video to show the glass-making process. In fact, the Museum of Glass's website provides several videos that could

meet this need. The other element of the visit – the gallery tour, the theater presentation and the art project could also be tailored to fit the resources of other museums.

**Case Study Conclusion**

The Museum of Glass provides an exemplary model for other museums that want to provide arts integration to their communities. The commitment shown by the Museum of Glass to integrate arts and sciences is great, indeed, the staff thought about arts integration as part of their museum design. This museum's staff members' attention to their programs and to evaluation processes is ongoing and they try to continuously adapt and change the programs to make them better. One of the key ingredients of this program is the outreach piece, which ties the museum closer to the schools. The outreach helps art or science teachers who are not comfortable with the integration piece to provide their students with this important learning without spending an undue amount of preparation time. "Emerson also mentioned that the lessons are more special and engaging because the lessons are taught by someone other than the regular teacher.[187] The museum visit is also very important and valuable as it exposes students to a museum setting that they might not otherwise have an opportunity to experience.

The Museum of Glass proves that museums do not need to have a varied collection of paintings, prints, or other objects; even narrowly focused museums can offer arts integration programming. Its arts integration program shows that many lessons can be developed from a single topic.

[187] Emerson, Interview, November 2014

## Conclusion:

## INTEGRATING THE ARTS AND SCIENCES IN THE MUSEUM SETTING

With the push for STEM education, many art educators are concerned about the single-minded focus on math and science. This focus has meant reduced funding for the arts and reduced classroom time to devote to the arts. Educators are concerned that STEM is placing the arts in opposition to the sciences and that arts are being pushed out of the schools. Many educators, both of the arts and of the sciences, are pushing back and becoming proponents of arts integration. These educators are looking for resources to affect this integration. Many museums have recognized this trend and they are creating arts integration programming to address these needs.

Arts Integration is an incredibly useful teaching strategy that can be utilized by museums to stay relevant in a changing world. Often, teachers, parents, and museum visitors are not just looking for a place to look at art or artifacts; they want these interactions to provide learning that meets educational standards and relates to the STEM emphasis in schools. And while STEM is at the forefront of education in the United States today, the business community, educators and politicians are also placing more emphasis on 21st century skills such as collaboration, creativity, communication and innovation. Museums have the opportunity to capitalize their expertise in these essential skills, all of which are an intuitive part of the museum education.

Through arts integration, museums support their communities. They also have the opportunity to introduce new communities to the treasures of museums. Often, when museums partner with schools, they are offering first time exposure to the arts to students.

These school audiences are often underserved populations who would not otherwise have access to museum resources.

Arts integration can also provide significant monetary resources to museums through grants. Organizations such as The Institute for Museums and Library Services, and the National Arts Education Association offer grant opportunities to museums to support their integration efforts, as does the U.S Department of Education through their Arts in Education initiative. As well, museums are likely to benefit from increased revenue generated from school museum visits and by offering professional educator workshops to teachers.

This thesis has presented five excellent examples of arts integration in museums. Each of these examples represent aspects that are important to the development of arts integration in museums. The Getty Museum's *Art and Science* curriculum emphasizes collaboration between science and art teachers in the teaching of arts integration lessons. The Getty's programming also provides flexible lessons plans and is designed to meet various educational levels. Its programming is also geared to meet national educational standards. The Getty Museum's *Art and Science* curriculum also shows the importance of utilizing the resources of the museum in preparing arts integration programming. They went outside the education department and consulted with other staff members including curators, conservators and scientists in the development of its lessons. Finally, they also consulted with teachers outside the museum.

The Museum of Mathematics is using arts integration to change the way people think about math. It is doing this through programming and exhibits showing the creative and aesthetic nature of math.

The Kennedy Center's *ArtsEdge* program reaches beyond the visual arts into music, dance and theater. *ArtsEdge* also importantly places emphasis on training the educator first. This program also encourages educators to review current research and emerging issues in arts learning to support innovative arts teaching. *ArtsEdge* reaches into schools, communities, and families by providing these groups with printed materials, on-line resources and classroom support services. Finally, *ArtsEdge* incorporates lessons designed for varying grade levels and provides programming to meet national and state standards for both arts and sciences.

The Walters Art Museum excels in arts integration programs that are intimately connected to the museum's collections and thus gives access to these objects to students who otherwise might not have the opportunity to learn about them. Also, while the program is geared to middle school students, it is flexible enough to be adapted to any grade level. The *Integrating the Arts* format is attractive to students as it offers an online interactive component to use in the classroom.

The Museum of Glass shows how a museum with a singular focus, in this case contemporary glass artists, can still utilize arts integration. Like the other programs above, its programming has the positive attributes of addressing learning standards and the flexibility to the lessons to be adapted to various grade levels. What makes this program unique among the museums reviewed here is the outreach programming this museum does into the school classroom. This classroom activity is designed to enhance the in-museum programming. The Glass Museum also works to insure the maximum value of its programming by constant evaluation and review.

Arts integration is a unique way for museums to utilize its collections and for Science Centers to use art to reinforce their disciplines, be it science, technology or mathematics. Arts museums can use it as a new lens through which to look at and share their collections. The 'whys' are many for museum education departments to adopt arts integration as part of their education programming. The IMLS writes,

> Museums and libraries house disciplinary experts who research, collect, and interpret artifacts, documents, and other aspects of material and written culture. They employ specialists who are well-versed in creating specific, content focused learning opportunities. These discipline-based partnerships can be a win-win for all parties. By partnering with schools, museums and libraries are able to contribute meaningfully to education while schools gain access to professional development, new curriculum and innovative pedagogy.[188]

Museums are places of authority on the knowledge they are presenting, signifying their role as leaders in the education field. As the above quote illustrates, museums are in a position to develop new curriculum and pedagogy that can transform the current education landscape. It is for this reason that this thesis is calling for museums to continue the push to integrate the arts and the sciences.

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[188] "Charting the Landscape, Mapping New Paths: Museums. Libraries, and K-12 Learning," Institute of Museum and Library Services, (April 2004) accessed December 10, 2014, http://files.eric.ed.gov/fulltext/ED495801.pdf, 20

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