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Museum3D: Engaging Audiences Using 3-D Printing and Scanning

Institute of Museum and Library Services Sparks! Grant Evaluation Report

Prepared by Uncommon Classrooms for The Art Institute of Chicago

"Maybe I'm not an artist or artistically inclined, but touching the piece wakes something up inside of you."

--Adult Tour participant

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EXECUTIVE SUMMARY

Executive Summary

In February 2013, the Digital Experience and Access department at the Art Institute of Chicago submitted a proposal for a *Sparks! Ignition Grant* from the Institute of Museum and Library Services. The proposal, titled *Engaging Collections in 3D*, sought to explore the following question: *Can cutting edge technology such as 3D printing be used to encourage a deeper, more meaningful, engagement with museum collections*?

Thus began a year-long investigation of 3D production and the visitor experience. A team of in-house educators and digital media facilitators, along with an external advisory committee and local and national partners, explored the central question through five programs for diverse audiences: families, adults, teens, tweens, and families. Using a variety of evaluation tools, we collected and analyzed data across programs and created a set of informed recommendations for future use by the Art Institute and peer institutions.

Our key findings do not provide a "yes" or "no" response to the central question. Instead, the findings help navigate the whats, hows, and whys around the question.

Key Findings

1. "Getting through the glass" is powerful. And possible.

2. Living fully in the 3D production ecosystem is healthy.

3. Program design significantly impacts program efficacy.

4. Encounters with 3D-printed objects provoke critical thinking about art.

See Results (below) for a detailed explanation of these findings.

PROJECT OVERVIEW

ORIGINAL INVESTIGATION

In February 2013, the Digital Experience and Access department at the Art Institute of Chicago submitted a proposal for a *Sparks! Ignition Grant* from the Institute of Museum and Library Services. The proposal, titled *Engaging Collections in 3D*, focused on the following question:

Can cutting edge technology such as 3D printing be used to encourage a deeper, more meaningful, engagement with museum collections?

The proposal included three supporting questions:

1. How can public programs use 3D printing and scanning to stimulate a richer visitor experience, both onsite and online, with our 3D object collections?
2. Does the process of this kind of collection access, capture, reproduction, design thinking, remixing and sharing allow for a deeper understanding of the artwork and the world?
3. How does this kind of engagement with the collection affect broader outcomes with our audiences? i.e. learning, interdisciplinary literacies, participatory communities, etc.

The internal team proposed an investigation through a series of five experimental programs reaching different audiences: families, adults, teens, tweens, and educators.

PROJECT RATIONALE

Through multiple front-end meetings, the internal team identified the project rationale and objectives.

Project Rationale **Why is the Museum experimenting with 3D printing programming?**	Explore the ways in which encounters with 3D production might impact the visitor experience with the museum collection
	Excite audiences about making, about the powers of creating/producing
	Encourage new/deeper interest in the Art Institute (in the collection, specifically)
	Encourage audiences to "look more closely" and "look differently"
	Encourage audiences to experience failing, iterating, and remixing
	Expose audiences to new technologies

PROJECT OBJECTIVES

Through a series of meetings, the internal team identified the project rationale and objectives.

Project Objectives **What does the Museum hope and expect to achieve through this experimentation?**	Design a new, impactful, engaging, transformational program
	Contribute to the broader informal art learning community, specifically re: collection engagement and experimentation with maker experiences
	Explore "this kind of programming" and determine what it means to the Art Institute
	Demonstrate specific qualities about the museum: it's an experimental place, willing to experiment, and visitors can experiment; it's a platform for creativity; it's a place for inquiry and to learn by doing
	Spark internal discussion re: specific pedagogies: object-based learning and new forms of digital media and learning

INFRASTRUCTURE

When conceiving of the original grant, and in executing the first month of project activity, department leads created an infrastructure to support program design and implementation.

Key Infrastructure Elements

Collaboration between two museum departments: Digital Experience and Access + Museum Education

Commitment to a formal evaluation process; hiring an external evaluator to work across all five programs

Creation of an advisory board made up of internal and external representatives; monthly meetings for sharing and development

Connection with local maker community for technical and pedagogical assistance

Collaboration with the School of the Art Institute of Chicago for technical and pedagogical assistance

Creation of project documentation (in addition to formal evaluation): project blog, program blog, and recordings of Google Hangouts

PROGRAM DESCRIPTIONS

Program #1:
Diwali Family Festival

The Diwali Family Festival took place November 9, 2013, from 10:30AM-3:00PM. The target audience was families with children ages 2-16. The program was drop-in; guests came and went as they pleased. A total of 671 people attended the 3D events (total festival attendance was 2,372). Family Programs and Digital Experience and Access representative staffed the program, with support from teaching artist Tom Burtonwood and interns from the School of the Art Institute.

Diwali Family Festival participants pose like ancient sculptures; Art Institute staff help create 3D scans of the poses

The program included a variety of participatory art activities in the Ryan Education Center (REC) and select Museum galleries. The 3D production activities were stationed in Classrooms 3 and 4 in the REC and in the Alsdorf Gallery of Southeast Asian Art. Activities in the REC were free; to visit the galleries, guests purchased a Museum admission ticket.

In the REC, participants sat (alone or with a parent, sibling, friend) on a swiveling platform and posed (ideally) in the style of a sculpture from the Alsdorf Gallery, of which there were pictures on a nearby wall. Facilitators captured the pose, and participants and bystanders watched as the digital recreation came to life on an overhead monitor. In an adjoining room, 3D artist Tom Burtonwood manned two MakerBot printers; participants observed the movement of the printers while asking Tom questions. In addition, participants made sculptures out of playdough using 3D-printed molds of objects from the Alsdorf Gallery, and handled 3D printed objects of museum collection artwork. The playdough activity was not planned and was set up on the spot to keep young hands busy.

In the Alsdorf Gallery, participants used AIC-provided iPods and iPads to photograph *Buddha Seated in Meditation* (or, if desired, another sculpture) by walking around it and capturing 20-40 images. Then, using Autodesk's 123D Catch software, participants created a 3D image of the sculpture and viewed/manipulated it. Participants also used the devices to view images from the gallery and scans other participants created earlier in the day.

Program #2:
Hands-On Tours for Adults

The hands-on tours for adults took place March 17 and 18, 2014. The tour on March 17 served guests with blindness or low vision; there were a total of seven participants. The tour on March 18 served guests with Alzheimer's Disease and other forms of dementia; there were a total of 10 participants. The tours, designed and led by the Assistant Director of Senior Programs, were 45 minutes in length.

3D-printed replicas of Museum objects used for hands-on adult tours

The tours provided a multi-sensory experience, activating sight (when/if possible), sound, and touch. Each tour featured four artifacts from different galleries. Participants wore headsets to amplify the tour guide's voice. Accompanying participants were volunteers to assist with repeating tour guide content, handling objects, and navigation.

In advance of the tours, museum staff 3D printed the object replicas. Staff selected objects from the collection that were originally meant to be handled. The printed objects were not the same weight or material as the original objects; they were printed (when possible) at a 1:1 scale. In the case of one object (Chinese bell), the replica was not 3D-printed, was the same material as the original object, and was smaller than the original object. In another case, a relief was printed onto an object that did not exist in the original.

At each stop on the tour, participants handled the replica objects while viewing and learning about the original artifacts, listened to music that related to the content of the objects, and interacted with the objects by making sounds from them (a bell, a whistle).

Participants on March 18 were scheduled for a studio art-making activity following the tour. Due to early arrival of the pick-up bus, and time spent on a post-tour evaluation interview, participants only had a few minutes to work on a modified version of the activity.

Program #3: Teen Lab

Teen Lab, the Art Institute's after-school program designed for high school students enrolled in Chicago Public Schools, runs twice a year, each time for 10 weeks. Teen Lab provides a space for teens to understand and push themselves as creative producers and thinkers through connection with the collection and within the context of the institution. Participants meet after school three times a week for three hours each session to experiment with new ideas and media, meet and mingle with museum staff and artists, have gallery discussions, and make lots of art. Students apply for the program and receive program awards for their participation. Teen Lab is run in partnership with After School Matters, a nonprofit organization focused on out-of-school-time opportunities.

Teen Lab participant and Teen Lab educator interacting with/through a 3D-printed sculpture (teen project)

The spring 2014 Teen Lab program ran from February-April and involved a total of 16 participants. 3D production, introduced a few weeks after program launch, was only one component of the Teen Lab curriculum, which focused more broadly on the value and meaning of objects in various contexts as well as what it means to consume and create objects. For three weeks, participants experimented with 3D production through scanning, designing, and printing. Teens then had the option to utilize 3D production in their final projects.

Two Museum educator/teaching artists ran the program, with assistance from a program assistant, other Museum staff, and a teen, who doubled as a participant and an intern. Specific support for 3D production was provided by a work-study student and a co-op intern from SAIC.

asm after school matters

Teen Lab is a partnership between the Art Institute and After School Matters

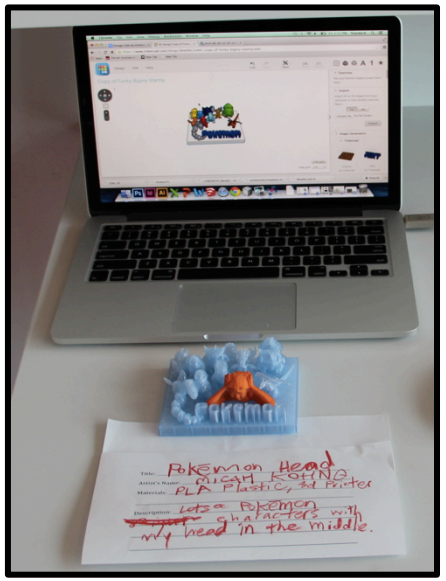
Program #4:
Tween Art Camp

Tween Art Camp, titled *Objects: Remixed, Reconfigured,* ran from June 23-27, 2014 at the museum. Participants, ages 8-12 from Chicago and the suburbs, came to the museum each day from 11:00AM-3:00PM. Participants applied to the program and received free tuition upon acceptance. A total of 12 students enrolled in the program.

The content of Tween Camp focused on the concept of remixing/reconfiguring. Tweens spent time in the galleries looking at mixed/remixed/mashed-up objects, in the studio making their own remixed work, and designing and printing original work on the 3D printer.

An educator from the museum ran Tween Camp, with help from staff, a digital teaching artist from the local maker community, a graduate student from the School of the Art Institute of Chicago, and a teen intern (a different teen each day). Technical support was provided by the Department of Digital Experience and Access and a recent graduate from the School of the Art Institute.

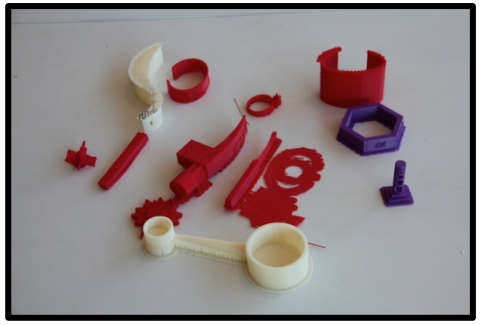
A total of 12 tweens—eight female and four male—enrolled in the program. One tween, a female, dropped out after the first day (did not cite a reason).



Pokemon Head;
final 3D-printed project
from Tween Art Camp participant
(Pokemon figures + scanned/printed self-image)

Program #5:
Educator Professional Development

The Educator Professional Development program took place July 9-11, 2014. Educators, who represented elementary, middle, and high schools from Illinois, came to the museum each day from 8:30AM-2:30PM. The program was fee-based (the other programs in the grant series were free, and one included a participant stipend).



Collection of 3D-printed objects created by educator PD participants

Teachers spent time in the galleries exploring original works of art and in the studio learning to use SketchUp, designing work, and producing work on the 3D printer. The thrust was disruption—taking a personal/memorable/significant object from home, intervening with that object's design and purpose, and printing a new version of the object.

An educator from the museum ran the program, with help from a professor at Columbia College, an intern from the School of the Art Institute of Chicago, and a graduate student from the School of the Art Institute of Chicago.

A total of 15 teachers—12 women and 3 men, a mix of middle school and high school teachers—enrolled in the program. Ten participants were art educators; the other participants were a mix of language arts and science educators. One student, a male, dropped out after the first day (citing reasons of dissatisfaction regarding content and pedagogy).

EVALUATION METHODOLOGY

FRAMING THE INVESTIGATION

Through a series of meetings, the internal team and advisory board created three central questions to guide the investigation. We developed several versions of these questions, which we based on the original questions posed in the IMLS grant. We committed to using these questions across all five 3D programs.

Evaluation Guiding Questions

1. In what ways (or to what degree) is engagement (in the activity, select objects, the AIC collection, and art-making) evident as audiences participate in 3D production programs?
2. In what way(s) does exposure to 3D production activities impact audience understanding and perception of the AIC collection, art objects, and art-making?
3. What are the identifiable factors that influence/impact program efficacy?

FRAMING THE INVESTIGATION

Guiding Question 1
In what ways (or to what degree) is engagement (in the activity, select objects, the AIC collection, and art-making) evident as audiences participate in 3D production programs?

Indicators of Engagement	
Dwell time (with object, with activity, in gallery)	Quantity and type/quality of questions
Looking closely (observing, noticing, tracking)	Connections (personal connections with work of art (1:1 "friends") or activity; between genres/media; between disciplines)
Focused action (interest in doing/completing activity)	Discernment (object: object; medium: medium; period: period; etc.)
Attachment to work output (interest in or appreciation of work created)	Curiosity (about the artist and work of art; art-making; how to learn/do more)
Quantity and type/quality of conversation	

Note: Other indicators of engagement (e.g., stickiness/memory, content understanding) were deemed too difficult to measure in the scope of this evaluation.

FRAMING THE INVESTIGATION

Guiding Question 2
In what way(s) does exposure to 3D production activities impact audience understanding and perception of the AIC collection, art objects, and art-making?

Impact of 3D Production on Understanding and Perception of:		
AIC Collection	Art Objects	Art Making
What the collection includes (and excludes)	Context for medium, genre, period	We make art because…
Why the collection exists (and why objects are considered valuable/ significant)	Value of originality, singularity	Art is made by…[artists] [machines] [me]
What's accessible to me—what I can do/see/experience at the museum	Value of original 3D objects (as aesthetic objects—sketches, experiments, detritus, etc.)	
Which objects/genres/galleries resonate with me	Value of 3D replicas	
What belongs here, what is art, as influenced by interaction with 3D making or viewing?		

FRAMING THE INVESTIGATION

Guiding Question 3
What are the identifiable factors that influence/impact program efficacy?

Audience Characteristics	Program Design	Differentiation	Object Selection
Age	Learning framework	Uniqueness of experience	Type
Ability	Program duration	New technology (paradigm shift)	Material
Prior Knowledge	Program setting	Multisensory experience (tactile + more)	Size
Readiness	Program structure	Access to the collection	
Motivation and/or interest	Facilitation	Access to art-making (digital access = easier access)	
Expectations	Peer mentoring	Three-dimensionality (printed, specifically)	
	Task complexity		
	Presence of a teaching artist or technical expert		
	Placement on functionary category spectrum		

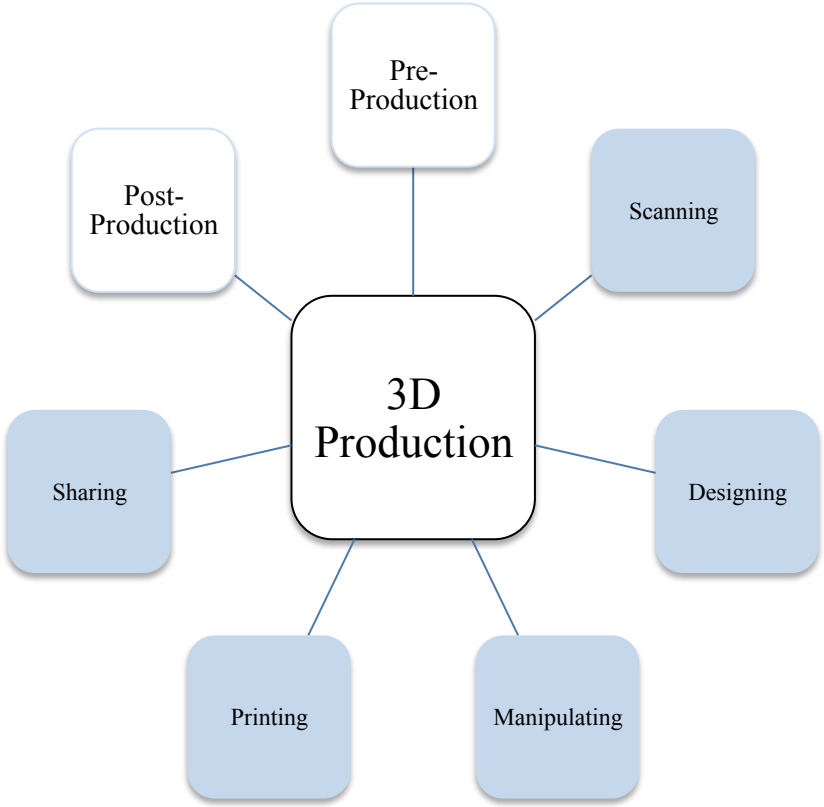
CREATING A FRAMEWORK

The original IMLS grant introduced the concept of a "3D production ecosystem." Thinking about an ecosystem with many components, rather than about a single step of printing a 3D object, proved useful throughout program design and evaluation in creating a more comprehensive understanding of possible interactions with this new media.

The internal team created a framework detailing the components and skills related to the 3D production ecosystem. We used this language throughout our conversations about program design, implementation, and evaluation.

A summary of how the grant programs ultimately mapped to the framework is included in the Results section of this report.

3D Production Framework (High-Level)



Note: Components are not necessarily experienced linearly.

CREATING A FRAMEWORK

3D Production Framework (Detailed)

Pre-Production
- Thinking
- Planning
- Conceptualizing
- Researching
- Communicating

Scanning
- Investigating three-dimensionality
- Looking closely
- Image capturing
- Troubleshooting
- Collaborating
- Communicating

Designing
- Investigating three-dimensionality
- Drawing
- Imagining
- Iterating/Revising
- Collaborating
- Communicating

Manipulating
- Iterating/Revising
- Critical thinking
- Communicating
- Remixing

Printing
- Prototyping
- Operating
- Troubleshooting
- Looking closely

Sharing
- Communicating
- Evaluating

Post-Production
- Using
- Responding
- Reflecting
- Remembering
- Iterating
- Evaluating

DESIGNING THE TOOLS

Observations

- Diwali Family Festival
- Hands-On Adult Program
- Teen Lab
- Tween Art Camp
- Educator Professional Development

Individual Interviews

- Diwali Family Festival
- Tween Art Camp
- Educator Professional Development

Group Interviews

- Hands-On Adult Program
- Teen Lab
- Educator Professional Development

Written Reflection

- Tween Art Camp

Self-Critique of Artwork

- Tween Art Camp
- Educator Professional Development

Survey

- Tween Art Camp

We designed and employed a variety of tools to accommodate the diversity of program design and audience.

See Appendix for copies of evaluation tools.

Evaluation Details: Diwali Family Festival

Evaluation Team
The evaluation team consisted of a lead evaluator assigned to the grant and two evaluation assistants who were graduate students from the School of the Art Institute of Chicago.

Protocol and Tools
Taking into account the program design and audience, we selected **observation** and **1:1 interview** as the two evaluation methods. The external evaluator collaborated with staff from Family Programs to design and refine the instruments.

Observations took place in the Ryan Education Center and the Alsdorf Gallery. Interviews took place in the Educator Resource Center, across from the classrooms where 3D activities were situated, as well as in the Alsdorf Gallery, on a bench at the gallery entrance. We selected families that could be tracked from start to finish of activity in the space (for observations) and/or who had fully participated in the activity (for interviews). We sought to achieve breadth of gender, age, race, family size. **A face: face debrief with program staff** was also part of the evaluation process.

Challenges
The key challenge with this evaluation was the timing of the program. The grant kicked off in October, and the Diwali Family Festival took place in November. Since we were just beginning to identify the central questions for the evaluation, we used a draft version for the Family Festival and a different (final) version for the remainder of the programs.

See Appendix for complete evaluation tools and protocol.

Evaluation Details: Hands-On Tours for Adults

Evaluation Team
The evaluation team consisted of the lead evaluator assigned to the grant. The manager from Digital Experience and Access handled photo documentation.

Protocol and Tools
Due to the small group size, we opted to design **focus group sessions** to capture a variety of perspectives/responses from participants. We also **observed the participants** during the tours and **interviewed select volunteers** via email. The external evaluator collaborated with staff from Adult Programs to design and refine the instruments. A **face:face debrief with program staff** was also part of the evaluation process.

Challenges
One key challenge with this evaluation was our inability to use control groups. Ideally, we would have run the same programs with sighted guests and guests without dementia, and/or we would have run different programs (same tour but without the 3D objects) with the same guests, and/or run the same program with the same audiences but with different object materials, and/or other combinations thereof. Control groups would have yielded more specific data about cause and effect.

Another key challenge was the limited amount of time available to conduct the second focus group (on March 18); we spent less than 10 minutes with the group. Further, this group, possibly (but not necessarily) due to the dementia disorders, had some difficulty reflecting on the tour content.

See Appendix for complete evaluation tools and protocol.

Evaluation Details: Teen Lab

Evaluation Team

The evaluation team consisted of the lead evaluator assigned to the grant and a graduate school assistant from the School of the Art Institute of Chicago.

Protocol and Tools

Due to the long duration (10 weeks, 30 sessions) and diverse curriculum (i.e., not focused only on 3D production), we opted to **conduct targeted observations** on six strategic program dates. The evaluation focal point was a **group interview** at the end of the program. A **face:face debrief with program staff** was also part of the evaluation process.

Challenges

One key challenge with this evaluation was the long duration of the program and large number of sessions; we were not present for a majority of the sessions and only collected data on the dates we were present. Also, because the curriculum focused on many forms of art-making, the evaluation's focus on 3D production was not entirely relevant to the student experience.

See Appendix for complete evaluation tools and protocol.

Evaluation Details: Tween Art Camp

Evaluation Team

The evaluation team consisted of the lead evaluator assigned to the grant. The manager from Digital Experience and Access, along with rotating (daily) teen interns, handled photo documentation.

Protocol and Tools

We covered a lot of ground with this evaluation, due to the small group size, the structure (consecutive session dates, lasting only one week), and the specific focus of the program on 3D production. We conducted **observations** of the group, **individual interviews** that focused on a **self art critique**, a **survey,** and a **daily writing/reflection exercise**. A **face:face debrief with program staff** was also part of the evaluation process.

Note: We had intended to distribute the survey in written form, and for participants to complete it individually. After observing the reading/writing skills of participants on earlier session dates, we felt an oral, group format would yield more substantive output.

Challenges

There were no significant challenges with this evaluation. The tweens were vocal about their boredom with the evaluation process, but this fact did not hinder efforts in a meaningful way.

See Appendix for complete evaluation tools and protocol.

Evaluation Details: Educator Professional Development

Evaluation Team

The evaluation team consisted of the lead evaluator assigned to the grant. A graduate student from the School of the Art Institute of Chicago handled the photo documentation.

Protocol and Tools

We spent the bulk of our time observing the program and listening to the conversation. In addition, we conducted **four individual interviews** and a **brief group interview**. A **face:face debrief with program staff** was also part of the evaluation process.

Challenges

The key challenge to this evaluation was the desire for the lead instructors to keep the methodology as open as possible going into the program, and to minimize the amount of program time spent on evaluation. We weren't sure what to expect or how to proceed from day to day. In the end, this challenge turned into an opportunity for evaluation trends to emerge in an organic—and ultimately illuminating—manner.

See Appendix for complete evaluation tools and protocol.

RESULTS

SIGNIFICANT FINDINGS

"Getting through the glass" is powerful. And possible.

- Multisensory experiences facilitate connection with the collection.

Living fully in the 3D production ecosystem is healthy.

- Participating in all components on the production spectrum leads to greater connection and discernment.

Program design significantly impacts program efficacy.

- Key sub-factors include facilitation, program setting, and program structure.

Encounters with 3D-printed objects provoke critical thinking about art.

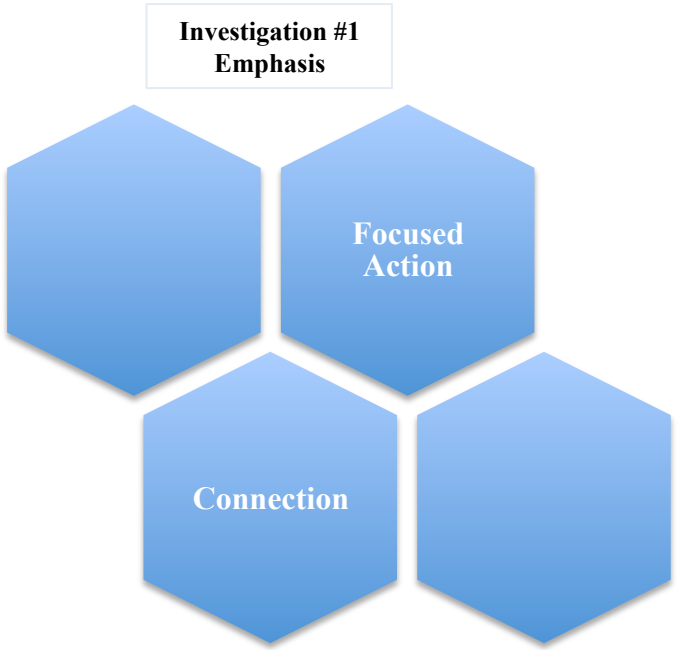
- Both making and viewing generate discussion about art, art-making, and artistry.

INVESTIGATION #1

In what ways (or to what degree) is engagement (in the activity, select objects, the AIC collection, and art-making) evident as audiences participate in 3D production programs?

At the start of the evaluation, we developed a list of engagement indicators to guide our work (see Evaluation Methodology).

As programming progressed, we simplified the investigation by honing in on two high-level engagement indicators that were measurable/relevant across the five programs: Focused Action and Connection.



Investigation #1
Results: Engagement/Focused Action

Focused Action Introduction

We measured focused action by tracking instances of dwell time (with an object, with an activity, or in a gallery); instances of looking closely (observing, noticing, tracking); participation in and completion of an activity; and attachment to work output.

While we employed a variety of evaluation methods throughout this grant, we assessed focused action primarily through observations. (In some instances, the individual or group interviews we conducted yielded additional data around this investigation.) We tracked and observed select participants at program sessions using a custom rubric. We counted behavioral and affective instances of the indicators listed above, totaled the number of instances, characterized instances, and calculated a final rating for each session. Next, we created an average for each program based on data across sessions within each program.

Please see the Appendix for complete details on protocol and copies of evaluation instruments.

Guests with low vision exploring the 3D-printed Greek Rhyton on a hands-on adult tour

"Touching is how we know everything."
--Adult tour participant

INVESTIGATION #1
Results: Engagement/Focused Action

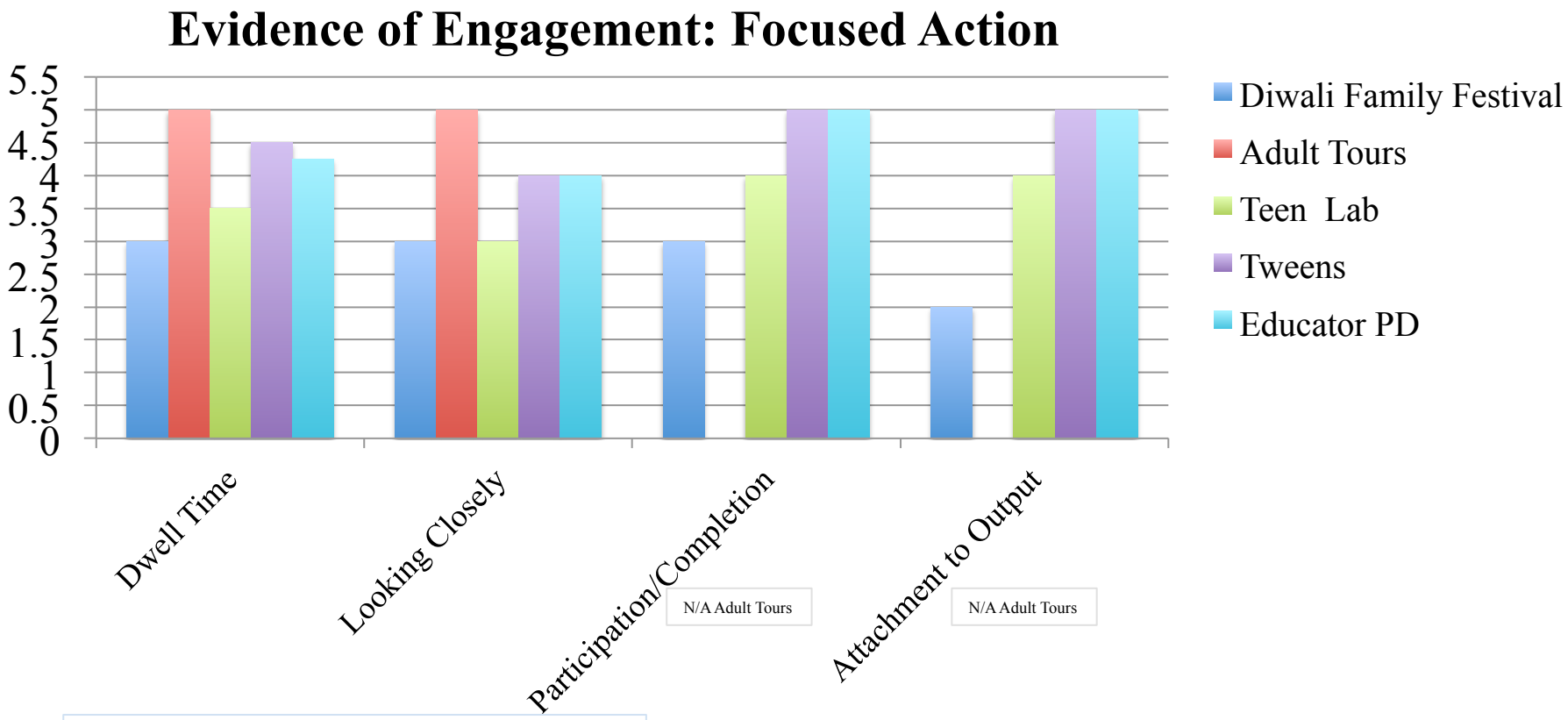


Figure 1: Evidence of engagement measured by focused action

INVESTIGATION #1
Results: Engagement/Focused Action

Focused Action: Discussion

Focused action through dwell time and looking closely were most evident in the hands-on tours for adults. The guided tour design, with specific stops and everyone following the same linear path, the presence of volunteers to keep participants on track, and the age and readiness of the audience, may be significant factors.

The group interviews we conducted with the adult tour group participants offered additional, specific explanation for their focused action. One participant cited “Lucas’s [the educator/tour guide] calm, engaging manner of asking questions and listening” as a key factor, and another said the facilitated tour brought the objects to life; on her own she “would have just walked right by.”

Most significant were the comments about the multisensory inputs, and how the ability to see, touch, and hear (or, in the case of the tours for guests with visual impairment, to touch and hear) the objects magnified the tour experience and generated the observed focus.

Activity participation/completion and attachment to work output were not applicable factors for the adult programs and were not tracked.

"I liked the fact that we could have the representation in our hand, feel the detail and size. It was better than having someone describe it."
--Adult Tour participant 1

"When something is described, you're taking someone else's impression/perspective. But if you give me the delicious pastry, then I can make my own decision about what it is.”
--Adult Tour participant 2

INVESTIGATION #1
Results: Engagement/Focused Action

Focused Action: Discussion, continued

Focused action was least evident in the family program. The Diwali Family Festival was a large-scale, drop-in program with activities distributed throughout the Museum. Participants had many things to do and see during their visit. In some cases, parents were rushed (e.g., a mother to her child: "I want you to take advantage of everything" and moving him along); children demonstrated lack of interest in completing an activity or seeing a final product (e.g., a child: "I don't need to wait around to see it, we can go,"); or families playfully documented themselves, instead of the original objects. Technical difficulties (perceived length of wait time for scans to generate, barriers to learning/ operating software or hardware) in some cases may have also hindered focused action.

There is, however, evidence to support focused action at the family program: affective behaviors and statements (smiles, "wow" statements,); participation in the activities provided (scanning, posing, making playdough molds, talking to the 3D artist); hacking the activity to make it their own; and more.

Internal staff report similar behaviors among parents and children at the Family Festival as observed at other large family programs, including the average amount of time families spent on the activities (per observations and interviews, 15-20 minutes).

"The scanning made the visit more fun. I was more interested in the sculpture because I could see the back of it and also inside it."
--14yo Family Festival female participant

INVESTIGATION #1
Results: Engagement/Focused Action

Focused Action: Discussion, continued

The Tween Art Camp and educator PD programs utilized a similar design: small group size, specific curricula with complex, detailed project requirements, consecutive attendance days, and a dedicated teaching artist in the room daily. These program design similarities may explain the data similarities. In both programs, select participants voluntarily put extra work into their project design/research/implementation outside of class time—just one indication of focused action at these programs.

Original object inspiration, 3D printed bracelet + sketchpad; final project from Educator PD participant

Video Game World; final project from Tween Art Camp participant

INVESTIGATION #1
Results: Engagement/Connection

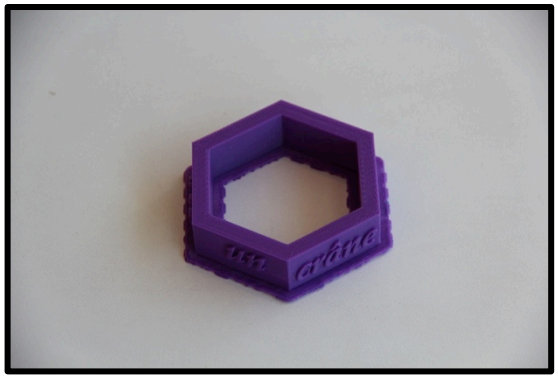
Connection: Introduction

We defined connection as developing resonance with the Art Institute—establishing a new or renewed intimacy with the collection. Specifically, we noted evidence of connection when we identified participants:

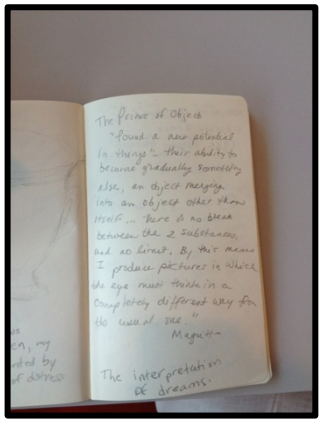
- developing a 1:1 relationship with an object
- making personal meaning based on a museum encounter
  - creating connections between gallery content and personal content, and vice-versa (could refer to worldview, art-making practice, experience, and more)
- demonstrating curiosity and/or interest in learning more (about a genre, gallery, artist, work of art)

We measured evidence of connection by interviewing participants and tracking statements related to these three indicators. We calculated averages for each indicator across the programs.

Please see the Appendix for complete details on protocol and copies of evaluation instruments.



This is Not a Skull;
3D-printed replica of personal bracelet;
final project from Educator PD participant,
based on visit to Magritte exhibition



Quote from Magritte exhibition captured by Educator PD participant; led to creation of Magritte-inspired bracelet (above)

INVESTIGATION #1
Results: Engagement/Connection

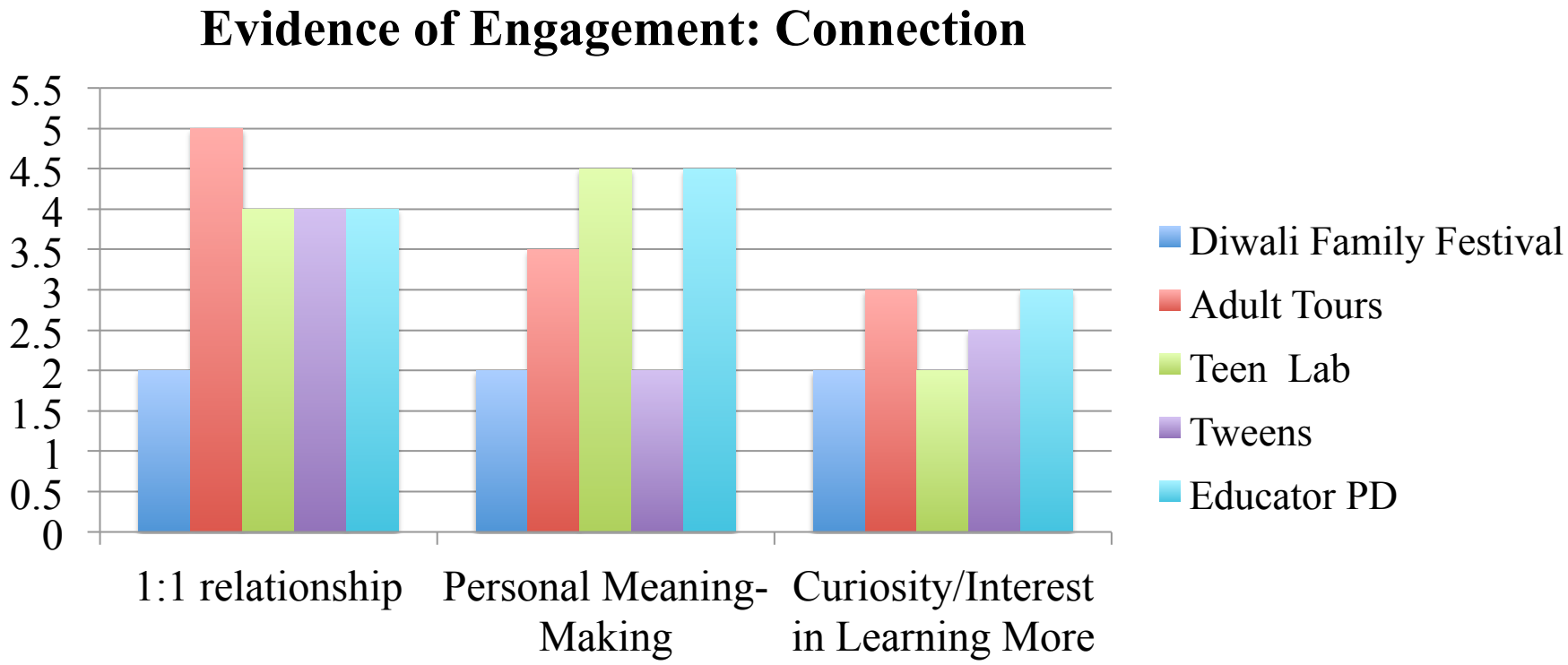


Figure 2: Evidence of engagement measured by connection

INVESTIGATION #1
Results: Engagement/Connection

Connection: Discussion

1:1 Relationship

The strongest evidence of 1:1 relationship development came from adults on the guided tours. This response is likely attributed to the self-described emotional experience—the awakening—created by the multisensory inputs.

"The object becomes a part of you, becomes a friend, much more intimate."
--Adult Tour Participant 1

"Touching awakens my imagination. I could see it better, but in a different way. Touching made up for lack of vision; it was a very emotional experience."
--Adult Tour Participant 2

The teen, tween, and educator programs yielded the same data levels (also high) for this indicator. It's important to note that these audience groups spent time in the galleries and classrooms (with far more time spent in the classrooms), whereas the adult tour was entirely gallery-focused.

The tweens reported the act of art-making and remixing as the primary reason for their new/renewed relationship with the museum.

Tour in action; guests with visual impairment

INVESTIGATION #1
Results: Engagement/Connection

Connection: Discussion

Personal Meaning-Making

Teen and educator program participants demonstrated the highest degree of personal meaning-making, as evidenced by the way participants framed their final projects.

Two case projects:

- *Domestic Suspension*, created by a participant in the educator program. This participant spoke of things she suspended due to motherhood. The object she brought from home to be disrupted was a diaper. She 3D printed a base/frame (a structure—representative of herself) with holes in it (representative of gaps in her self). She chose this modality after visiting the Joseph Cornell boxes in the galleries.
- *Lost,* created by a participant in Teen Lab. This participant spoke of a pen her sister bought her from Japan, which she lost. She envisioned a 3D print but moved to clay sculpture. She also made a notebook for classmates to record lost items and related feelings.

Note: both the teen and educator programs included a complex art-making activity.

Domestic Suspension; 3D-printed object; final project from Educator PD participant

Lost; clay molded pen + mixed media notebook; final project from Teen Lab participant

INVESTIGATION #1
Results: Engagement/Connection

Connection: Discussion

Curiosity

We measured curiosity (about the artist and work of art; art-making; learning/doing more) by observing the quantity/type of questions and conversation among participants and between participants and instructors (including teaching artists, graduate students, technical assistants, and more).

Participants on the hands-on adult tours asked the greatest number of questions related to the collection. This program took place entirely in the galleries and did not include an art-making activity.

The majority of questions from participants in the other programs related to technology: how the 3D printers work, what they are made of, what the possibilities are, how to do x or y, and the like.

At the educator program, significant time—about one hour on two separate days—focused on questions related to implementation: practical, technological, and pedagogical. This emphasis is typical of teacher workshops.

Tween Art Camp participants observing the MakerBot in action and interacting with SAIC graduate students

"I can relate to it better; I may want to go get book and look it up and get insight."
--Adult Tour Participant

INVESTIGATION #2

In what way(s) does exposure to 3D production activities impact audience understanding and perception of the AIC collection, art objects, and art-making?

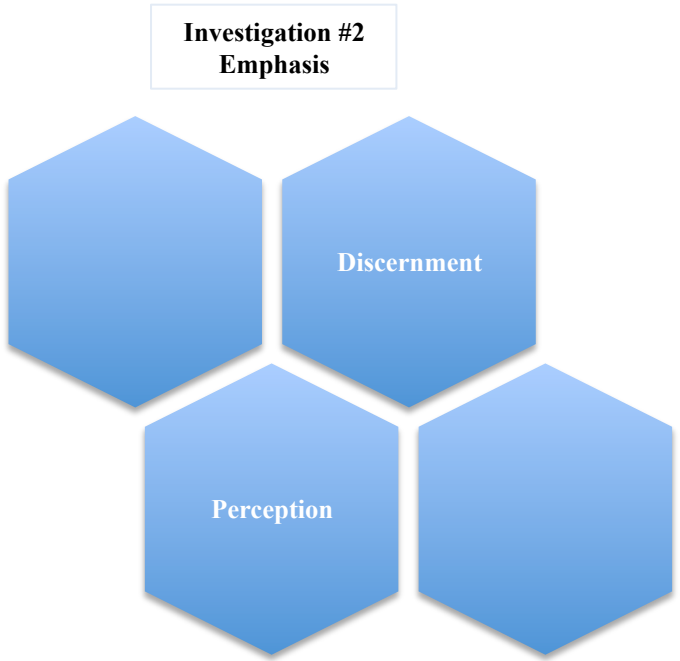
Although the original question used the term "understanding," we determined that "discernment" more accurately represented our intended investigation. This section, therefore, focuses on the impact of 3D production programming on participant discernment and perception of the Museum, art objects, and art-making.

For discernment, we sought to explore the ways in which participants:

- discussed Museum identity/content: what's at the Museum; what are the objects: history, medium, relationship to other objects
- responded to a self art-critique
- demonstrated expansion of ideas (about the Museum and art in general (what art is, what art can be, who/what can make art))

For perception, we sought to explore the ways in which participants:

- discussed art, art-making, and artistry in relation to traditional and digital fabrication
- discussed concepts of originality and singularity



Investigation #2
Results: Impact/Discernment

Discernment: Introduction
We investigated the impact of 3D production programming on the outcome of discernment by employing the following evaluation tools:

- Observations: all programs/audiences
- Individual interviews: families, adults, tweens
- Group interviews: teens, educators
- Written self reflection: tweens
- Survey: tweens
- Self Art-Critique: tweens, educators

Please see the Appendix for complete details on protocol and copies of evaluation instruments.

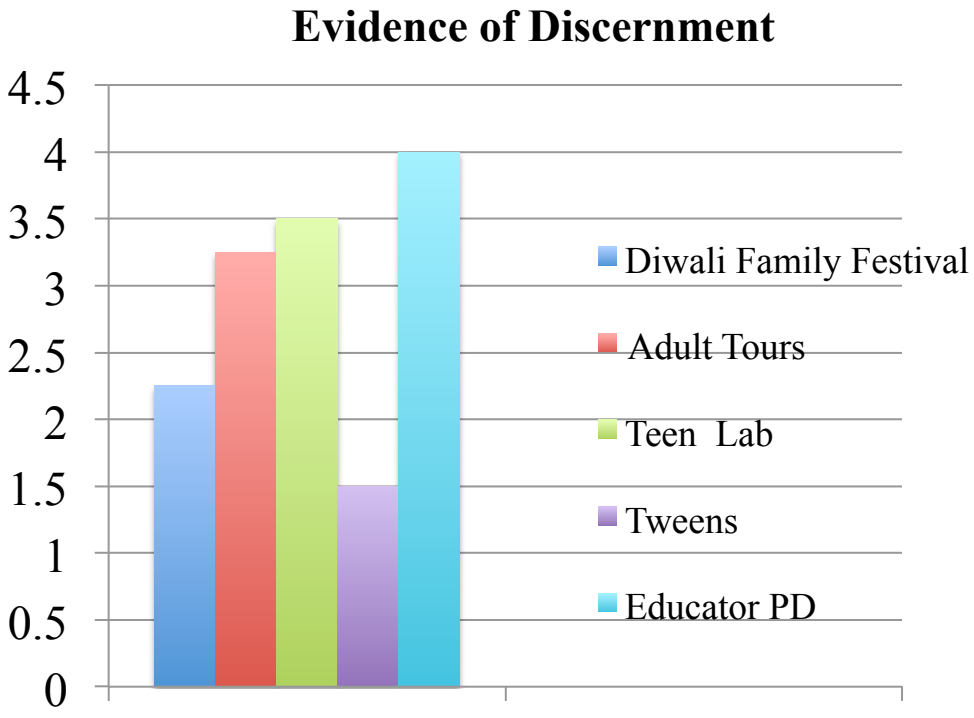


Figure 3: Evidence of impact measured by discernment

Investigation #2
Results: Impact/Discernment

Discernment: Discussion

Identity

Educators and teens demonstrated the highest degree of discernment related to museum identity. Adult program participants also demonstrated a high degree of discernment.

3D-printed house; final project from Teen Lab participant

During observations and in group and individual interviews, teens and educators recollected gallery experiences (naming and stating opinions about specific works of art; mentioning genres) as well as artists who were introduced during museum classroom time. Many of the educators were full-time art instructors and likely came to the program with significant prior knowledge.

In the family program, parents demonstrated some understanding of museum content (e.g., "this mold is of a sculpture that's here, and we can go see it"). When interviewed, children were unable to speak with any meaning or specificity about any of the objects they had encountered. Tweens, too, were unable to discuss museum content with substance. This fact may not reveal lack of impact for children at the festival or for tweens—but rather lack of maturity and developmental capacity to synthesize complex topics.

We were unable to parse the data to determine the impact of 3D production (in particular, vs. general program participation or time spent in the museum) on discernment.

Investigation #2
Results: Impact/Discernment

Discernment: Discussion, continued

Self-Critique

We conducted art self-critiques with tweens and educators. We adapted Edmund Burke Feldman's model of art criticism and interviewed participants about the work they created and the work/process of 3D production. Interviews walked participants through Feldman's categories of Description, Analysis, Interpretation, and Judgment.

The educators' responses to the self-critique revealed understanding and opinion about their work, the Museum collection, 3D production, and connections therein.

With one exception, the tweens did not present meaningful connections between their work and the Museum and were unable to think critically about their work or the process of 3D production. We conducted the self-critique with the tweens prior to the educators. We used the same process and questions with both groups. We believe the tool is flawed; the questions (the wording, quantity) were too complex for a tween audience.

"With clay, it's much more tactile; you can feel what you are making. It's the same amount of hard/easy but actually a little harder because on the printer I didn't know how to do anything and someone had to help me. It's much more complicated unless you know what you're doing."
--11yo female Tween Art Camp participant

"This process aligns with the design process: brainstorming, tinkering, working with media, formulating ideas, prototyping, iterating, going back."
--Educator PD Participant

Investigation #2
Results: Impact/Discernment

Discernment: Discussion, continued

Expansion

We sought to explore the concept of expansion—the possible ways in which contact with 3D production impacted participants' ideas about the Museum and art in general (what art is, what art can be, who/what can make art). Expansion is related to both discernment (examined in this section) and perception (next section).

Questions related to expansion were part of our conversations with teens, tweens, educators, and families. These questions were not part of our conversations with adult tour participants.

We recorded a variety of statements to support evidence of expansion related to 3D production access, but we did not collect quantitative data around this idea. Tweens completed a daily reflection exercise answering three key questions related to discernment (and more); at the end of the week, we analyzed the daily responses and measured expansion. This exercise did not yield useful data and cannot be extrapolated to tell a story across programs.

"It's neat to see that art is not just pen and paper" / "Seeing sculpture shows breadth—what art can be."
--Two different Family Program participants (parents)

"I learned that there are new ways to make art and sometimes it's better."
--9yo male Tween Art Camp participant

"I have a broader appreciation than what I thought of before. [This] opened my eyes more to museum things and what could be in it."
--Teen Lab participant

"This [3D printing] gives everybody chance to be artist."
--Teen Lab participant

INVESTIGATION #2
Results: Impact/Perception

Perception: Introduction
We investigated the impact of 3D production programming on the outcome of perception through the following evaluation tools:

- Group Interviews: teens, educators, tweens
- Self Art-Critique: tweens, educators

Our discussions with participants centered around the ideas of originality, singularity, and handmade vs. digital fabrication.

We weren't searching for a binary judgment from participants; instead, we wanted to see whether or not encounters with 3D production provoked meaningful discussions about art. The data clearly supports evidence of this provocation.

Please see the Appendix for complete details on protocol and copies of evaluation instruments.

"The 3D objects are not trash but they are not something that would go in museum. They are something in-between. I don't really know the value. They are something interesting.

The ones in the galleries are much more valuable because they are old and by famous painters and artists."

--11yo female Tween Art Camp participant

"What happens to value of something? If the method is same then value is the same. If it's the same energy into artwork and conveys the same emotion to viewer, then same meaning. Artwork is emotion—no matter if stone or 3D printed object."
--Teen Lab participant

"Can't beat the feeling when standing in front of the original painting. American Gothic: I have stood in front of it, purchased every reproduction. I went to the original home and saw the original window and baked a pie. You can't reproduce that."
--Educator PD participant

Investigation #2
Results: Impact/Perception

Perception: Discussion

Both the teen and educator groups engaged in intellectual discussions about their perceptions of art, art-making, and artistry. Neither conversation offered a definitive conclusion; as participants pointed out, perception is subjective.

The main text framing the educator program was *The Work of Art in the Age of Mechanical Reproduction* by Walter Benjamin (1968). Led by workshop instructors, educators spent some time during each day of class discussing the idea of "aura" (of the handmade object, of the singular and/or original object, of the 3D-printed object) and debating the complexity of different art-making forms.

One participant, in the middle of the discussion, asked the group, "what about the aura of the handmade?" He revealed a collection of miniature handmade pots and proceeded to gift one to each participant. This participant, a full-time art teacher and potter, was fully engaged in 3D production throughout the workshop. His action provoked conversation, but we have no reason to believe he was making a positive or negative judgment.

Drone;
final project by Educator PD participant
(potter)

Investigation #2
Results: Impact/Perception

Perception: Discussion, continued

In their group interview, the teens discussed/debated where art/mastery lies—in the concept/idea or in the method—and what gives an object its value.

From one student: "Donatello's David—how he used strictly marble, didn't use other media. Marble is really really hard. How he sculpted it; it looked smooth and polished. It was much harder for him to do that. It's much easier today to print. Anybody can be an artist. If you have ideas and materials you can just print it; versus education, going to classes, spending time sculpting." For his final project, this teen made a work titled *Old Art vs. New Art.*

This comment, and others from the teens, revealed how encounters with 3D objects provoked exploration around handmade and printed work.

Old Art vs. New Art; final project by Teen Lab participant

"To be honest, I really didn't like carving. It was more time consuming compared to 3D printing." --Teen Lab participant

Investigation #2
Results: Impact/Perception

Perception: Discussion, continued

We asked participants from different programs to discuss the value of objects (what makes something valuable, what is the value of a 3D-printed object), to use their own words to characterize 3D-printed objects, and to state whether or not 3D-printed objects are "art."

The Figures on the next few slides provide the output from those discussions.

Teens argued both for and against the value of 3D-printed objects, and the list of adjectives from teens, tweens, and educators is as wide-ranging as the participants themselves.

When asked to make a judgment about whether or not 3D objects are art, the tweens were comfortable with a binary response, while some educators qualified their "yes" judgment with a maybe/but/if statement.

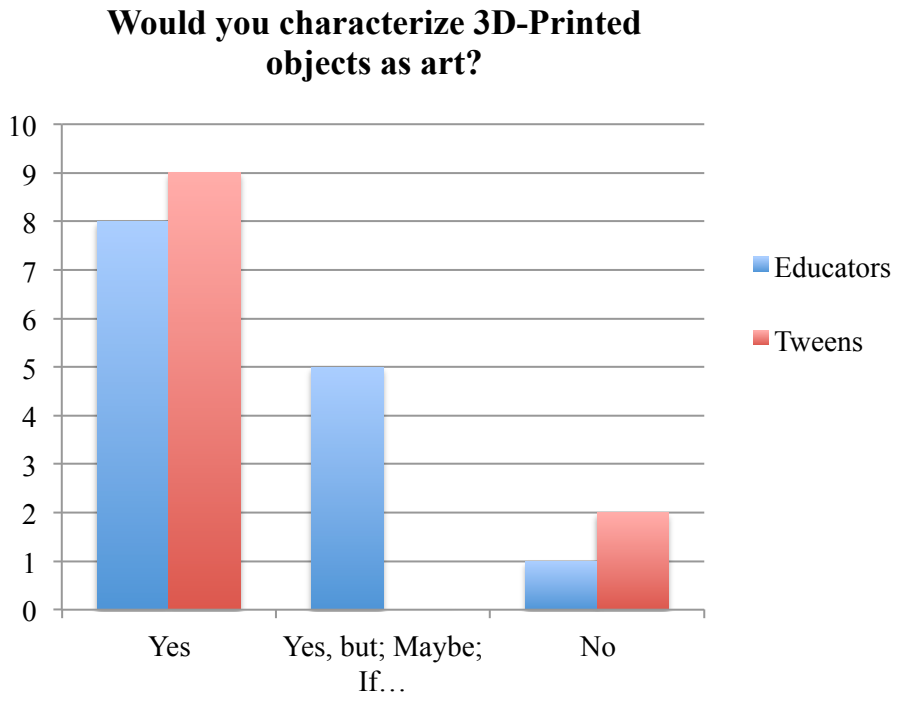


Figure 4: Exploration of value based on characterization as art

Investigation #2
Results: Impact/Perception

Teen Lab Responses to Questions about Value

What makes something valuable?

- age
- meaning
- something you have opinion about
- rarity
- story behind it
- depends on artist
- old art
- where it's from
- if you can't touch it
- what it's made of
- art you don't understand when you first see it
- different for everyone
- connection…personal, physical; anything that makes you feel something or sparks something

What's the value of 3D-printed objects?

- depends on what you make with it
- it's less satisfying to know you didn't physically create it; I like creating art with my own hands; takes part of artistic style away
- depends on what's being printed
- 3d printing puts value on different skills (e.g., math, computers); not less value, pretty sure making that programing was difficult
- depends on what input it
- value is subjective, different for each person; value you place on object will change; some people see black dot and others have back story; could see it as something done a million times or so beautiful because it was done a million times
- saw a piece at the museum, forget name; saw tree and was inspired by that; had men come and carve every detail; didn't use his hands to carve each detail; does that mean he wasn't the illustrator of the piece? Was he not the creator?
- takes away, not your art because it's not your hand; but it's still your art because it's your idea

Investigation #2
Results: Impact/Perception

Participant characterizations of 3D-printed objects

Educators	Tweens	Teens
futuristic	cool	filament
wonder	awesome	object
lightweight	imagination	art
beautiful	great	repurposed plastic
layered	captivating	corn starch
mechanical	complicated	idea
automated	plasticy [sic]	worthwhile
geometric	unique	complex but simple
sterile	amazing	
innovative	fun	
rigid		
fusion		
engineered		

INVESTIGATION #3

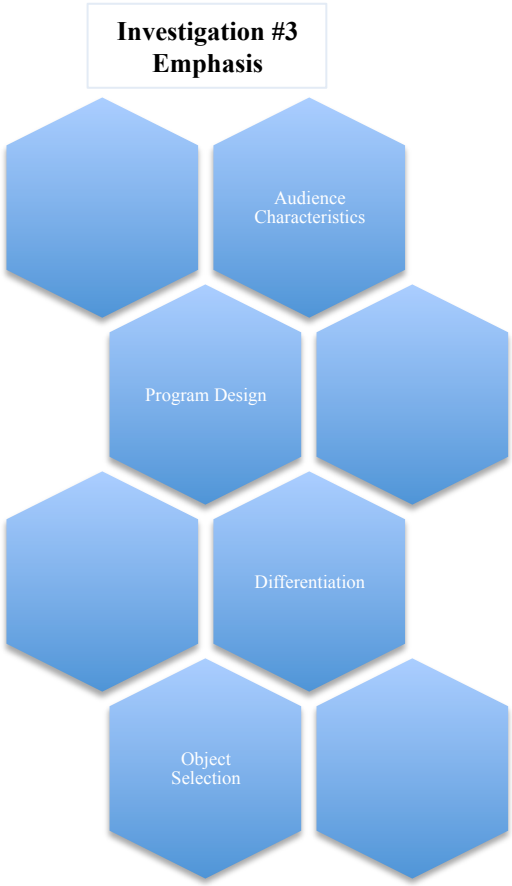
What are the identifiable factors that influence/impact program efficacy?

The quantitative data in this report only tells one part of the story. The data tells what happened—what we observed, what people said. But the data does not discuss the "whys" behind the story.

To get at this next level of information, we conducted debriefs with leads for each program to explore the weight of four variables on program efficacy—the ability for the program to achieve its intended outcomes.

We explored the following four factors:

- Audience characteristics
- Program design
- Differentiation
- Object selection



Investigation #3 Results: Factors

Factors: Introduction
The data charts represented in this section are based on discussions with internal museum educators and on program observations. We ranked the sub-factors within each main category based on staff emphasis and on perceived impact at programs.

From our staff debrief discussions and program observations, we were unable to collect enough data around audience characteristics to support an intellectual discussion. We know that audience make-up is a factor, and we suggest further investigation.

Please see the Appendix for complete details on protocol and copies of evaluation instruments.

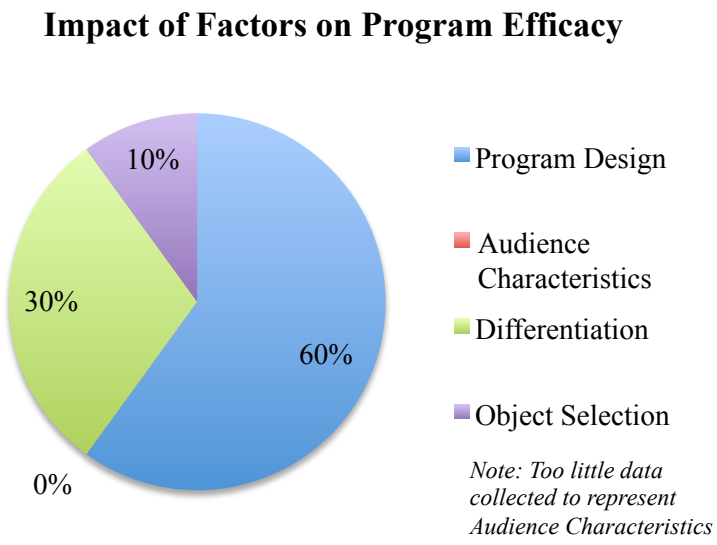


Figure 5: Impact of factors on program efficacy

Investigation #3
Results: Program Design

Factors: Discussion
Debriefs with internal staff confirmed parallels between this program series and other (non-3D) programs regarding data in this section. Thus, we cannot draw conclusions about program design that relate specifically to 3D production.

The most significant sub-factor within program design was facilitation—the presence and strength of museum staff, teaching artists, and technical assistance. This group, responsible for program content and pedagogy, tailored programming to meet the needs of distinct audiences, interpreted the museum collection and helped make connections between visitors and museum content, and inspired the act of art-making.

At Tween Art Camp, the ratio of facilitator: student was 1:2. At the educator program and at Teen Lab, the ratio of facilitator: student was 1:3.

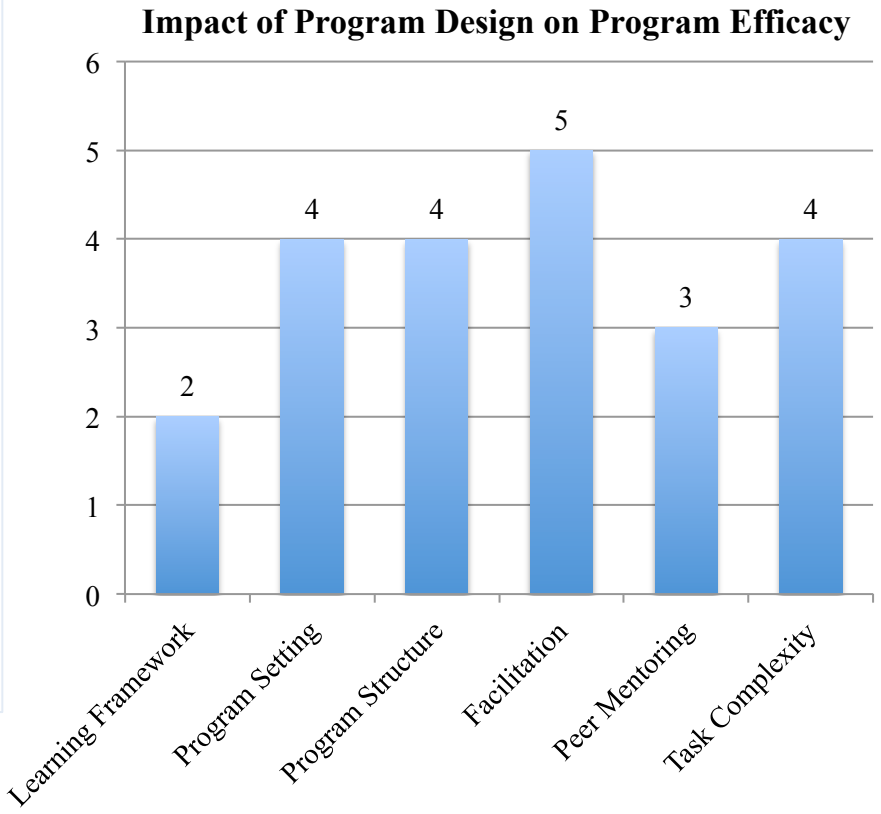


Figure 6: Impact of program design

Investigation #3
Results: Program Design

Factors: Discussion, continued
In addition to facilitation, significant factors within program design included program structure, program setting, and task complexity.

The different structures we investigated included drop-in/non-structured (Family Festival); structured/linear (Hands-On Tours, Teen Lab, Tween Summer Camp, Educator PD); one day (Family Festival, Hands-on Tours); and multi-day (Teen Lab, Tween Summer Camp, Educator PD). We also investigated program duration (less than 1 hour, 1-2 hours, 2-3 hours, 3-4 hours) and contact consistency (consecutive vs. interrupted).

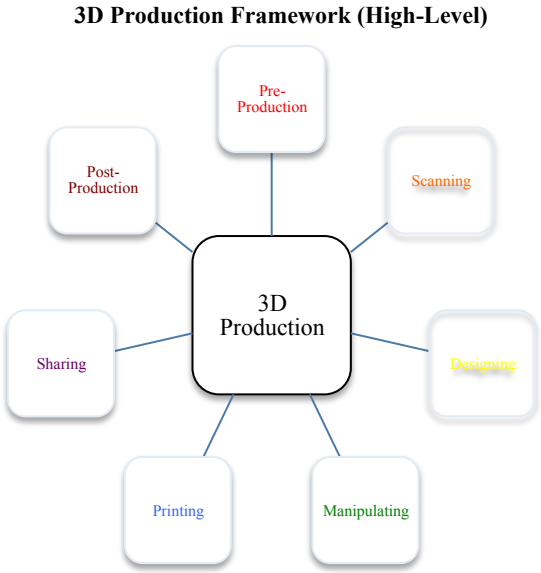
The different settings we investigated included classroom/studio, gallery, and blended. All of the programs but the Hands-On Tours featured a blended setting (a classroom/studio was planned for one tour but was cut short).

Higher impact was correlated with structured/linear and multi-day structures, and with longer duration and consistent contact.

The Hands-On Tours yielded high impact in relation to measured outcomes despite the short duration, limited contact, and absence of an art-making activity. This exception may be due to a variety of factors: a well-designed tour, strong (per participant feedback) facilitation, and the unique way in which a multisensory experience impacted this particular adult audience. As discussed previously, the use of control groups in future investigations will reveal more specific data.

INVESTIGATION #3
Results: Program Design

Factors: Discussion, continued
To investigate task complexity, we studied the 3D production ecosystem and mapped each program to the framework. The teen, tween, and educator programs involved the full 3D production ecosystem and featured complex art-making projects. These programs yielded high impact in relation to measured outcomes (see previous slides). Again, we note an exception with Hands-on Tours. We suggest further investigation of causation and correlation in this area.



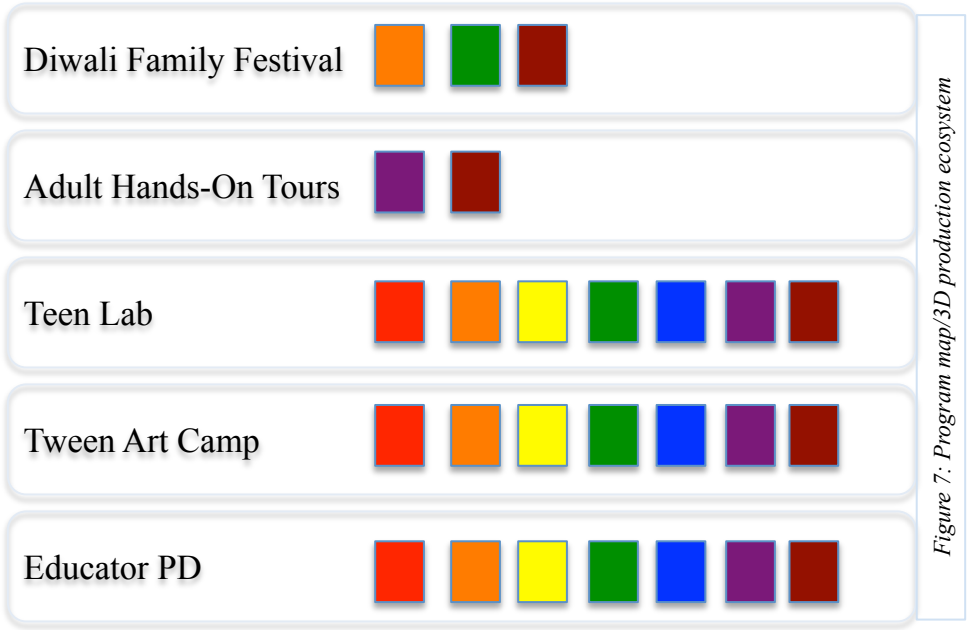


Figure 7: Program map/3D production ecosystem

INVESTIGATION #3
Results: Differentiation

Factors: Discussion, continued
Initially, we posed this question about 3D programming:

- What differentiates this form of "making" from other art-making experiences and this form of "viewing" from other art appreciation experiences at AIC?
    - Is it the three-dimensionality? The process of engaging with a new tool (and/or this particular tool)? Designing for a 3D world? The objects themselves? Other?

As programming progressed, we explored a different question:

- What makes the 3D programming experience different for audiences, and what is the impact of those differences?

The data in this section is from Tween Summer Camp participants, whom we surveyed directly.

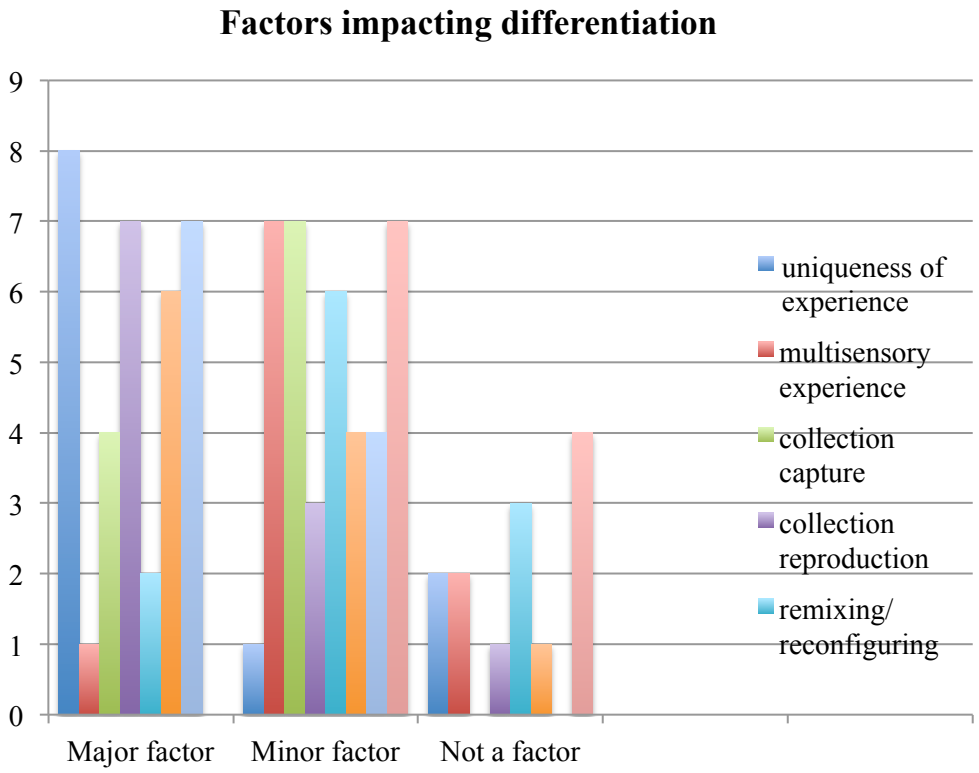


Figure 8: Factors impacting differentiation (per tween survey)

INVESTIGATION #3
Results: Differentiation

Factors: Discussion, continued
As part of the survey, we asked Tween Summer Camp participants to identify specific impacts of their encounters with 3D production.

- The act of **planning my project** helped me understand the museum and connect with the collection better because:
  - made me think more like an artist; what I should do when planning to make a nice work of art
- The act of **scanning** helped me understand the museum and connect with the collection better because:
  - now I know that 3D printing is at the Art Institute
  - paid attention to the details of the sculpture
  - it's a way to remember each piece
  - get to see all of the angles of it and see everything about it, just not a quick glance
- The act of **remixing work** helped me understand the museum and connect with the collection better because:
  - at first I didn't know that artists did that
  - gives a whole new meaning to chemistry
- The act of **3D printing work** helped me understand the museum and connect with the collection better because:
  - now I know when I come here they have 3D printers
  - shows how LEGOs or little toys are made
  - now I know what these are made of and how
  - now I know people can make things like sunglasses, earrings, necklaces, other accessories
- The act of **sharing work** helped me understand the museum and connect with the collection better because:
  - can see what other people make and what they think of; gives you ideas
  - gives you motivation and inspiration and ideas for own creation
  - makes me feel like I'm an artist whose picture is in the Art Institute; other people can look at it and comment on it

Figure 9: Impact of 3D encounters (per tweens)

INVESTIGATION #3
Results: Object Selection

Factors: Discussion, continued
Finally, we investigated the impact of object selection on the visitor experience. This question was most relevant for the adult tour groups, since they were working with and responding to printed objects only; there was no art-making component of their program.

We learned that the replica objects, despite being different sizes, weights, and materials from the original objects—and despite being copies of the original—were fully welcomed by participants. The Museum educator for this program states, "[participants] asked questions about the original object's material, suggesting recognition that the plastic 3D model was of a different material and knowing the original material was important. Not that the plastic material was inherently inferior! The difference in material became a vehicle for engagement."

In the educator program, questions about replica vs. original surfaced. The conversation focused more on perception, however (see Investigation #2), than on the need for replicas of a different type.

"I'm so used to going to AIC and everything is glassed up. Hands-on opens up your other senses and makes your heart putter, even though it's not the actual piece. Knowing that someone can duplicate this piece is thrilling."
--Adult Tour participant 1

"Coming into this, you know touching it isn't something we are able to do; the replica is our way of getting through the glass and 'seeing' it."
--Adult Tour participant 2

"There is nothing like standing in front of the original art, but the copies make it possible for people who can't see the original. Sometimes the relationship with the copy can be better than with the original."
--Educator PD participant

RECOMMENDATIONS

RECOMMENDATIONS

Design multisensory experiences to facilitate greater connection between visitors and the collection.

- 3D printing offers a relatively easy, inexpensive way to create replicas for use in programming.
- Work to integrate other senses as well—sound, taste, smell—into program experiences.

When possible, design 3D production experiences that involve the full production ecosystem.

- Feasibility of this idea depends on program goals, audience, duration, and other constraints.

Focus on facilitation, program setting, and program structure when designing new experiences.

- Conduct additional research to unpack the other factors that may impact program efficacy.

Invite participants to explore what art, art-making, and artistry mean to them.

- Use the 3D objects to spark investigation of the Museum collection, and vice-versa.
- Include audiences of all ages in this conversation.

ROADMAP FOR FUTURE 3D PROGRAMMING

Roadmap

Museums3D was an experimental endeavor for the Art Institute. The internal team committed to taking note of significant lessons throughout design and implementation, with the goal of remediating programming in subsequent years. Lessons learned are also documented for use by other museums and libraries interested in 3D production programming.

We codified lessons learned into a roadmap, which includes the following categories:

1. Planning
2. Collaborating
3. Staffing
4. Facilitation
5. Setting Expectations
6. Equipment
7. Safety

Roadmap: Planning

- **Do your research.**

There are a lot of options when it comes to 3D production software and hardware. What you choose will depend on your budget, program design, audience skill level, staff capabilities, room capabilities, and more. Spend proper time researching the right direction for your programming to set yourself up for success.

- **Create a project/program infrastructure.**

Upon kick-off, the project leads created an infrastructure that they utilized for all programs. Several components of this infrastructure—particularly collaboration with internal and external experts—were adhered to closely and turned out to be key factors of program success.

- **Pilot, practice, document.**

Leave ample time prior to program kick-off to 3D print the objects needed during the program, pilot the activities using the dedicated software/hardware, and create any necessary technical documentation to ease the visitor experience.

- **Remember your audience.**

Can an eight-year-old sit still long enough to produce a successful self-scan? Will a teen stay on task after being at school all day? The programs at the Art Institute were successful partly because the (very experienced) educators carefully mapped the programs to the anticipated needs and interests of the different audiences.

- **And yet...**

Good planning is an essential component of any program. But 3D production programming (or any programming involving technology, or any program that is experimental in nature) must also feature nimble design and implementation. Something that has never been done before or that is new/risky cannot be planned in full. “Planning” for that open-endedness, and responding in the moment to whatever occurs, is important.

Roadmap: Collaborating

- **Bring in the expertise you need.**

Debriefs with staff repeatedly revealed the important role collaboration played in program success. In particular, museum educators pointed to the significance of collaborating with the Department of Digital Experience and Access (DEA), which improved pedagogy (in terms of integrating new media in thoughtful ways) and and reduced technical complications.

Collaboration with teaching artists, the maker community, graduate students (and recent graduates) from the School of the Art Institute also greatly contributed to program success. Several educators stated that this grant facilitated their first intensive collaboration with DEA and that they are looking forward to continued partnership.

Roadmap: Staffing

- **Staff appropriately.**

Determine the number and type of staff you'll need based on the number of activities planned, the number of different program spaces, and the estimated number of participants.

- **Be realistic about staff constraints.**

Be realistic about what's feasible to implement, given audience prior knowledge, the unique setting that a museum provides, and the complexity of working with 3D production software and hardware. Be ambitious and experimental, but set yourself—and therefore your audience—up for success by setting realistic expectations about what your staff can handle in a given day.

Roadmap: Facilitation

- **Strong facilitation is key to program success.**

As outlined in Investigation #3, the most significant aspect of program design—impacting program efficacy—was the presence of strong facilitators. Included in this umbrella term is internal educators, external teaching artists, and interns (from graduate schools, high schools, and other). Gather and train the necessary troops to implement a successful program.

- **Technical assistance is also key to success.**

When designing the program, factor in the right level (per program complexity, audience size, internal expertise, and more) of technical experts needed for implementation. These experts play a crucial role in assisting with pre-production of 3D objects, handling the 3D production software and hardware, and assisting with fabrication and post-production cleanup.

- **Teaching artist: must-have or nice-to-have?**

The presence of a teaching artist enables participants unique access to an expert in the field. Carefully outline the role of the teaching artist, and ensure that his/her presence and expertise are evident during programming. Depending on the context of programming—art museum, science center, etc.—a teaching artist may be a nice-to-have. At the Art Institute, given the questions under investigation (related to new ideas about art), and given the newness of 3D production in museum settings (at the time of the grant), a teaching artist was a must-have.

Roadmap:
Setting Expectations

- **Product vs. process.**

Some 3D production programs are about product, or process, or both. Set expectations ahead of time so participants know whether or not they will be walking away with finished work (in hand or online). Be sure that expectation-setting includes the estimated amount of time required to make new work (i.e., it's possible to walk away with finished work, but you'll need to spend xx minutes/hours waiting, etc.).

- **"Glitch is Good."**

Be clear (with yourself and your audience) about the complexity level of the task, and the inherently messy nature of technology-based (especially 3D printed-based) programming. If frustration and failing are tenets of the program, be clear about that. This quote from the Educator PD program stands out: "I'm so confused and don't know what I'm doing and don't know where to begin." Ultimately, this teacher powered through and felt accomplished, but the context of the workshop supported that level of frustration.

- **Prepare for the known barriers.**

Make a list of known barriers—based on previous programs of a particular type (family, teen, etc.) at your institution, and based on previous tech-based (and/or specifically 3D printer-based) programs (at your institution or elsewhere). The known barriers to 3D printing are: complexity of software programs, time required to wait for scans and prints, inexperience with hardware, foreignness of 3D printing, and more.

Roadmap: Equipment

- **Determine how much equipment you'll need.**

How long will it take participants to complete the activity? How many participants will you have? Based on that (and other information, like how long devices will stay charged, etc.), determine the quantity of equipment.

- **Determine how you will be servicing equipment.**

What is the process—and who is responsible—for refreshing supplies and recharging or fixing equipment?

- **Make sure your room can accommodate your equipment needs.**

What amount of light will you need in the room? Do you have enough power outlets? Do you need/have an overhead projector?

Roadmap: Safety

- **Safeguard equipment.**

Devices—especially small ones—have a way of disappearing, especially in public spaces. Create a way to organize and track all equipment that is used for programs.

- **Safeguard participants.**

The mechanical movement of a 3D printer is mesmerizing to watch. Choose equipment with safeguards, so curious hands and fingers are not in contact with moving parts or hot filament.

- **Test and vet.**

Work with software that has been tested/approved (not always possible with experimental programming but it's ideal).

- **Prepare the room properly.**

Be sure electrical cords are routed safely around tables and taped to the floor to eliminate tripping hazards.

- **Staff accordingly.**

Plan to have staff nearby, closely monitoring equipment that is in use.

APPENDIX

Appendix Contents

Please see separate file for Appendix.

A. Diwali Family Festival Evaluation Instruments
   - Observation tracking sheets
   - Individual interview questions

B. Hands-On Tours for Adults Evaluation Instruments
   - Observation tracking sheet
   - Group interview questions

C. Teen Lab Evaluation Instruments
   - Observation tracking sheet
   - Group interview questions

D. Tween Art Camp Evaluation Instruments
   - Observation tracking sheet
   - Self-reflection exercise
   - Survey questions
   - Art Self-Critique questions

E. Educator PD for Evaluation Instruments
   - Observation tracking sheet
   - Group interview questions
   - Art Self-Critique questions

Additional Documentation

- Project Site and Blog: http://museum3d.artic.edu/2013/11/06/about/
- Teen Lab Blog: http://arcticartic.tumblr.com

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