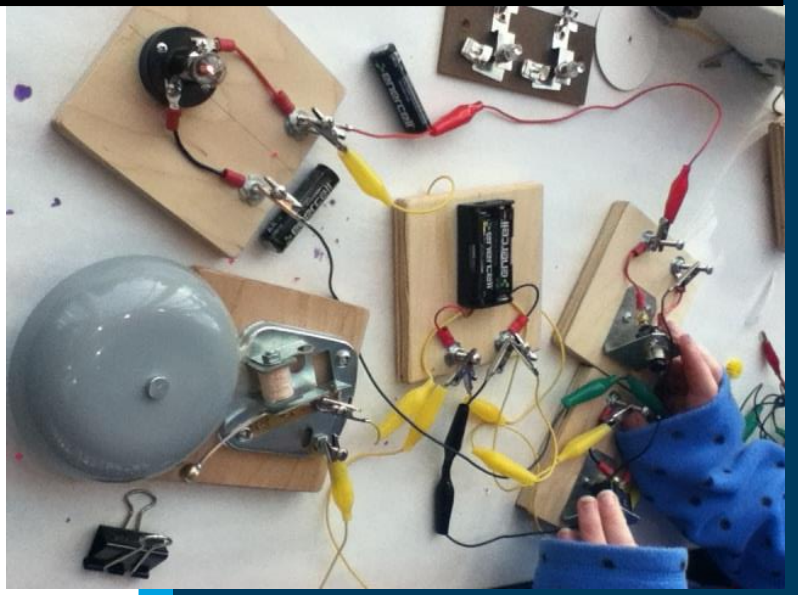
2019

Design, Build, Test, Repeat!: Tinker Tank Evaluation



Created by the Evaluation Department

Pacific Science Center

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Executive Summary

Purpose of Project

Pacific Science Center (PacSci) received a two-year grant from the Institute of Museum and Library Services (IMLS) to develop and test a variety of evaluation and assessment tools in its makerspace, Tinker Tank. Tinker Tank is a guest-directed, hands-on design space where participants are challenged to use their creativity, problem-solving skills, and experience to persevere through roadblocks, discover new approaches, and solve fun engineering tasks. Museum makerspaces, including Tinker Tank, share common goals. These goals include "self-directed learning, embracing and learning from failure, personally expressive and individually meaningful outcomes, discovery of the familiar and unfamiliar, and collaborative possibilities."[1] However, due to the nature of makerspaces, determining how best to define and measure success as well as selecting evaluation methods and tools is a challenge. PacSci developed and tested a variety of evaluation and assessment tools in Tinker Tank in order to determine which best assesses outcomes and goals. Year one (2019) of the grant focused on developing tools adapted from informal learning settings.

This report highlights the methodologies, evaluative tools, and findings from year one of the project in which five data collection tools were developed, tested, and finalized.

Image description: Tinker Tank makerspace with guests moving throughout the space. There is a Discovery Cart in the middle of the frame.

Overview and Approach

Tinker Tank's theory of change (appendix A) directed the project design and informed the development of the evaluation instruments to best asses the guest impact. In year one, PacSci's evaluation team developed evaluation instruments based on instruments currently and regularly used to assess learning and impact in informal settings. These instruments included observations, interviews, and surveys. Evaluation of Tinker Tank focused on the makerspace's facilitated activities. The facilitated activities have a defined purpose, unlike the more open-ended activities like Legos. The facilitated activities also most embody the principles outlined in Tinker Tank's theory of change and was identified by the Tinker Tank team as an important area of focus to better improve programming.

Inspired by the ethos of Tinker Tank, *"Design, Build, Test, Repeat!"*, the evaluation team explored a variety of methods, tested each instrument, and modified and refined instruments in accordance with testing results. Consistent collaboration with the Tinker Tank team contributed to the iterative process until each instrument reached its final iteration and the evaluation team created a data collection protocol. The evaluation team analyzed the collected data and presented preliminary findings to the Tinker Tank team. Data findings and Tinker Tank input informed year two's (2020) focus.

[1] Pacific Science Center. (2018). *Building Evaluation Tools for Measuring PSC's Makerspace Success*.

Findings

Visitor Engagement Framework

Pacific Science Center's evaluation team adapted Dr. Chantal Barriault's Visitor Engagement Framework (VEF) to best suit the needs and space of Tinker Tank. The VEF accounts for 10 behaviors, grouped into three categories. These categories include 1) Initiation (orientation to activity), 2) Transition (once oriented, more purposeful and committed actions), 3) Breakthrough (shows commitment to experience). Utilizing the modified framework, PacSci evaluators conducted 108 observations of guest behavior in Tinker Tank's facilitated activity space. The most in-depth and deep learning occurred at the Breakthrough level. This included behaviors such as *"Referring to past or future experiences"*, *"Seeking and sharing information with others"*, *"Sense of accomplishment"*, *"Engaged and involved: Testing variables, making comparisons"*.

PacSci evaluators also noted the ways guests engaged in the activity. Guests engaged in the activity by making a project, facilitating the activity for a group member, or doing both. All guests observed displayed Breakthrough behaviors. However, guests who were both making a project and facilitating the activity for a group member were more likely to display a Breakthrough behavior than guests who were solely making or solely facilitating.

Data Highlights

51% of all guests displayed a Breakthrough behavior.

Of the guests who participated in the Rocket activity…
72% of guests displayed a Transition behavior.
78% displayed a Breakthrough behavior.

33% of facilitators displayed a Breakthrough behavior.
55% of makers displayed a Breakthrough behavior.
63% of guests who were facilitators and makers displayed a Breakthrough behavior.

Interview

An interview instrument developed out of a need to understand behavioral nuances observations were unable to capture. PacSci's evaluation team interviewed three-hundred and seventy-six (376) guests. In interviews, guests responded to a question about whether they would like to do a similar activity again in the future. Nearly all respondents said yes. When asked why they would like to do a similar activity again, guests under the age of 18 years said they enjoyed the activity. Guests over the age of 18 who had children said the children were what compelled them to want to do a similar activity again.

When asked if they had engaged in a similar activity in the past, over one-third (38%) of 259 guests said they had not done anything like the activity before that day.

When asked to describe what they had been thinking about while working on the Tinker Tank activity, a common response was their goal, whether that included the process of defining that goal or determining how to achieve it. The second most common response was the external source of inspiration that sparked their idea.

Data Highlights

96% of all guests said they would like to do a similar Tinker Tank activity again in the future.

Motivation for doing a similar activity
Under 18 - Enjoyment
Over 18 with children - Children

38% of guests said this was the first time they had engaged in a makerspace activity.

Common thoughts while working on the activity
The goal
Inspiration for idea

Dimensions of Learning Framework

Pacific Science Center's evaluation team adapted the Exploratorium's Dimensions of Learning Framework (DoLF) to understand the behaviors observed in Tinker Tank through a different lens than the VEF. The DoLF consists of 14 behaviors grouped into four Learning Dimensions. These categories include 1) Engagement, 2) Initiative and Intentionality, 3) Social Scaffolding, and 4) Development of Understanding. The evaluation team conducted 69 DoLF observations. The majority of observed guests displayed a behavior from the Engagement Learning Dimension, which included the following behaviors *"engaging in Tinker Tank activities"* and/or *"displaying motivation or investment".*

Observable learning behaviors varied depending on who was (or was not) facilitating the Tinker Tank activity. Guests who had Tinker Tank staff facilitators displayed more learning behaviors in two Learning Dimension categories, Social Scaffolding and Development of Understanding, than guests who experienced facilitation from a caregiver or other PacSci colleagues (Tinker Tank volunteers, Youth & Family Programs staff, and Science Interpretation Programs staff). In contrast, guests who received facilitation from a caregiver expressed more behaviors in the "Initiative and Intentionality" Learning Dimension than guests who experienced facilitation from Tinker Tank staff.

Learning behaviors differed depending on whether a child or adult participated in Tinker Tank activities. Children more often displayed behaviors focused on setting goals, seeking and responding to feedback, requesting help, and connecting to other's work. Adults sought and responded to inspiration and offered help in solving problems.

Data Highlights

90% of all guests engaged in Tinker Tank activities.
61% of all guests displayed motivation or investment.

Tinker Tank facilitating…
Social Scaffolding
33% of guests requested help in solving problems.
33% of guests offered help in solving problems.
33% of guests inspired new ideas or approaches.
38% of guests connects to others' work.

Development of Understanding
29% of guests expressed realization of an approach/outcome.
29% of guests applied prior knowledge or engaged in work that is more complicated.

Learning Behaviors
Under 18 – Set goals, sought and responded to feedback, requested help, and connected to others.
Over 18 with children – Sought and responded to inspiration and offered help.

Think Aloud

PacSci evaluators conducted 12 think alouds as a method to understand guests' thoughts as they engaged in a facilitated activity. The ways Tinker Tank guests participated in the activity varied. Five guests initially engaged with the activity by setting a goal or intention. Four guests initially engaged with the activity by seeking and responding to inspiration, which consisted of guests looking to materials, already made creations, or fellow Tinker Tank guests from which to draw inspiration. In total, guests verbalized five different ways of initial engagement.

Data Highlights

Initial engagement of Tinker Tank activity
5 guests set a goal or intention.
4 guests sought and responded to inspiration.
1 guest gathered materials.
1 guest referenced past experiences.
1 guest facilitated experience for group member.

Four of the 12 guests iterated on their Tinker Tank activity creation. Iteration was defined as the process of modifying or adding to a design or creation after conducting a test. Depending on the Tinker Tank activity, testing could include testing for lights to turn on, robots being able to draw, and/or declaring a creation completed only to continue modifying and adding to the creation.

Interactive Multiple Choice Survey

Data Highlights

72% of guests tinker *"to have fun."*
53% of guests make for themselves.
34% of guests go to Tinker Tank to make.
51% of guests say tinkering makes them feel happy.

Guests who participated in the interactive multiple-choice survey responded five questions. These questions including 1) How old am I?, 2) Why do I tinker?, 3) Who do I make for? 4) Where do I go to tinker?, and 5) Tinkering makes me feel…. When asked why guests tinker, the five answers provided on the interactive survey included the following options: *"To make something for others"*, *"Because I have to"*, *"To have fun"*, *"To solve a problem"*, and *"To experiment"*. Nearly three-fourths of survey respondents said they tinker *"to have fun".* When asked where they go to tinker, nearly half of Tinker Tank guests who participated in the interactive survey said they tinkered in their home, and the second most selected location was Tinker Tank. The last question on the interactive multiple-choice survey asked Tinker Tank guests to identify how tinkering made them feel. Half of survey participants said that tinkering makes them feel happy, one-third said tinkering makes them feel proud, and an additional one-third said inspired. Less than one-tenth of guests selected negative emotions, and said that tinkering makes them feel frustrated or disappointed.

Conclusions and Recommendations

Visitor Engagement Framework (VEF)

Observations indicate that depending on the activity, guests will experience different Transition and/or Breakthrough behaviors. Rockets saw the highest percentage of Breakthrough behaviors while Tinkering with Bridges saw the least. Additionally, Up in the Air saw the highest percentage of Transition behaviors, while Tinkering with Bridges also saw the least. All learning has value. So it is recommended that the Tinker Tank team explore and select facilitated activities that encourage learning behaviors they wish to foster.

Data also implies that guests who both facilitated and participated in a Tinker Tank activity displayed more Transition and Breakthrough behaviors than guests who exclusively facilitated or exclusively participated. It is recommended that the Tinker Tank team explore and/or develop multigenerational activities for the Tinker Tank space. It is also recommended that further data be collected as sample size is small.

Interviews

Interviews were centered on understanding Tinker Tank guests' experiences with being pushed outside their comfort zone. Occurrences that prompted these feelings included lack of inspiration or running into a roadblock in construction of their project. Methods to overcome these feelings included looking to examples, following a diagram, or changing construction materials. It is recommended that the Tinker Tank team continue to include examples for all facilitated activities. If there is interest in fostering feelings of frustration, consider removing examples and/or diagrams, or adding an additional challenge to the activity.

Nearly all guests said they would do the same facilitated activity again, although depending on age the motivation varied. Enjoying the process of making or tinkering and/or enjoying the nature of the facilitated activity was the primary motivator of repeating the activity for participants under the age of 18. Adults were motived by their children, whether that was for entertainment and/or wanting to encourage children's' learning.

Dimensions of Learning Framework (DoLF)

Similar to the VEF, DoLF measured a variety of learning behaviors by observing certain behaviors. In general, guests more readily engaged in the facilitated activity and displayed motivation for the activity, but were less likely to take risks or inspire others with new ideas. They were also less likely to display behaviors indicative of understanding the approach or outcome of the facilitated activity. Data also indicated that the facilitator influenced which behaviors were exhibited. When Tinker Tank staff facilitated activities, guests displayed more social scaffolding behaviors than when caregivers or volunteers facilitated activities. Further research on Tinker Tank facilitation techniques would be recommend to better understand how to foster specific behaviors and learning dimensions. It is also possible that Tinker Tank staff may self-evaluate and provide modeling or education for other facilitators to engage participants in engaged ways.

Think Alouds

Think alouds provided a unique opportunity to understand the process of making as guests participated in the activity. Small sample sizes provide a more qualitative understanding of the experience, but also limits generalizations of the data. Findings follow the trend of both VEF and DoLF in that guests either set a goal/intention or sought and responded to inspiration as their first engagement. Analysis of transcripts also found that some Tinker Tank participants verbalized thoughts that had little or nothing to do with the facilitated activity. Consider exploring activities that connect to the guests' personal life if there is interest in fostering these connections. Think alouds may also be beneficial periodically when testing new activities.

Interactive Multiple-Choice Survey

During the period of data collection, data from this survey provided insight into the age, motivation for tinkering, for whom they make, where they go to make and tinker, and how tinkering makes them feel. Findings are consistent with data from interviews in that guests make to have fun. They also make for themselves and their families and tinker at home or at Tinker Tank. Guests also experience positive emotions when tinkering. Guests 13 years of age and older were more likely to tinker to experiment, to solve a problem, or to make something for others. Teenagers (13-17 year olds) were more likely to make for themselves and their families. However, for guests five years of age and older, they typically tinker at home. It is recommended to collect data periodically throughout the year or when the Tinker Tank makerspace experiences major changes to continuously gauge guests' experiences. It may be worth exploring how to engage adults in the makerspace by incorporating challenges or contributions to 'real world problems.' This may also encourage making and tinkering at Tinker Tank.

Introduction

Tinker Tank Background

Tinker Tank, Pacific Science Center's makerspace, is a visitor-directed, hands-on design space where participants are challenged to use their creativity, problem solving, and experience to understand the processes of science. Tinker Tank starts with the premise that everyone is curious and a natural problem solver. Tinker Tank appeals to all ages, genders, developmental abilities and socioeconomic statuses by providing a consistent and empowering environment that encourages visitors to engage in situations and challenges that push their ability to solve problems.

Image description: The Tinker Tank makerspace prepped with materials for AstroDrop. Materials include markers, tape, scissors, cardboard, and paper.

The rotating offering of hands-on facilitated activities in Tinker Tank run the gamut from exploring phenomena (gravity and aerodynamics) to learning how things work (circuits and toy/small hardware take-apart) and engaging design challenges (wind-powered vehicles, cardboard city, building bridges). Designed to appeal to the entire spectrum of PacSci guests, Tinker Tank activities are as deep and complex as the guest chooses to make them, and learning outcomes differ based on the connections each participant makes. Each activity has a goal, but allows many paths to arriving at a solution.

The facilitators in Tinker Tank are of a specially recruited group of staff and volunteers, most of whom have backgrounds in science, math, engineering and technology (STEM). Facilitators are trained in inquiry-based learning methods to encourage participants to experiment with materials and then find the best way to fulfill their design ideas. Facilitators support participants by asking questions and modeling thinking and tinkering skills. In addition to these core facilitators, PacSci staff from other departments, such as Science Interpretation Programs and Youth and Family Programs, also help facilitate activities in Tinker Tank.

PacSci's Tinker Tank is grounded in the organizational mission, which is to "ignite curiosity in every child, and fuel a passion for discovery, experimentation and critical thinking in all of us." With its emphasis on self-directed learning, embracing and learning from failure, discovery of the familiar and unfamiliar, and collaborative possibilities, Tinker Tank is a key component in achieving Pacific Science Center's strategic guiding principles for modeling science as a process for our guests and community; embracing experimentation and innovation; enabling access for all; and supporting formal educators.

Project History

Funded by the Institute of Museum and Library Services (IMLS) Museums of America grant, PacSci's evaluation team sought to assess outcomes and goals of the organization's makerspace, Tinker Tank. This project allows PacSci to determine which tools, adapted from both informal and formal learning settings, are able to be adapted and implemented to provide meaningful data about the learning and engagement that occurs in Tinker Tank's makerspace. Tinker Tank's Theory of Change (ToC) informed the development of the evaluation instruments. Tinker Tank's ToC is a three-pronged approach (see Appendix A); starting with the premise that "Tinker Tank is a place where guests can *make something that does something.*" The three methods Tinker Tank implements includes the following:

1. "*We encourage exploring novel approaches to challenges…SO THAT guests experience feelings of surprise, delight, and wonder, WHICH LEADS TO guests generating new question based on their own curiosity, AND IN TURN are inspired to follow through and act on their ideas.*
2. *We emphasize making and tinkering, failure and iteration…SO THAT guests are pushed past their comfort zone, WHICH LEADS TO a sense of accomplishment, AND IN TURN guests feel empowered to seek out more making experiences.*
3. *We provide a trusted, safe place, tools and materials, and people…SO THAT individuals interact and build connections based on shared experiences, WHICH LEADS TO Tinker Tank being seen as a hub of making and tinkering education in the Seattle community, AND IN TURN repeat engagement fosters stronger connections with neighbors.*

Image description: Pop-up makerspace activity located in PacSci's Upper Building Three. The Tinker Tank activity is experimenting with circuits. There are four people, two PacSci guests and 2 PacSci staff, in the background.

Ultimately, Tinker Tank contributes to building a city in which all people are equipped to tackle challenges in innovative ways with confidence."

In year one (2019) of the project, PacSci's evaluation team developed five evaluation instruments adapted from informal learning settings to help assess approaches one and two of Tinker Tank's ToC. See appendix B for finalized evaluation instruments and protocols.

Evaluation Instruments Adapted and Informed by Informal Learning Settings		
Instrument	Source	Adaptations
Visitor Engagement Framework (VEF)	Chantal Barriault, PhD., Laurentian University & Science North Canada	The VEF is well suited to hands-on exhibits and experiences. PacSci's evaluation team considered the differences between engagement with interactive exhibits and engagement with a makerspace when adapting the instrument. Initial observations of Tinker Tank aided the adaptation of the instrument in order to capture behaviors observed in the makerspace. Additional adaptations included the documentation of contextual information specific to Tinker Tank (e.g. type of activity, group composition, time spent, etc.).
Interviews	Tinker Tank VEF	The interview instrument developed out of the data obtained from the VEF. Evaluators were able to ask guests directly about their experience participating in a Tinker Tank facilitated activity. Changes in question phrasing focused on understanding the feelings of being outside of one's comfort zone and understanding the sense of ease when a guest did not experience feeling outside of their comfort zone. Additional adaptations to the instrument also included questions about repeat engagement and whether (or not) guests had previously engaged in a similar activity. The instrument went through five iterations before it reached its final state.
Dimensions of Learning Framework (DoLF)	The Tinkering Studio, Exploratorium	The Tinkering Studio, located in the Exploratorium of San Francisco, CA, developed a framework to assess different ways of learning in their makerspace. Adaptations to the instrument included matching behaviors observed in Tinker Tank with behaviors identified in The Tinkering Studio's DoLF. Behaviors observed in Tinker Tank would inform the adaptations of the original DoLF. Majority of adaptations focused on the Engagement learning dimension. Additional changes to the framework included the addition of Tinker Tank's Theory of Change (ToC) and aligning the goals identified in the ToC with the learning dimensions, indicators, and description of learner's interactions.
Think Alouds	User-Experience protocol; Tinker Tank interviews	PacSci evaluators decided on a think aloud instrument as it naturally built on the interview, producing a greater variety of qualitative data, and allowed insight into the thought process of guests as they engaged in a Tinker Tank facilitated activity. This method asked guests to say whatever came to mind as they completed the activity. This included what they were looking at, thinking, doing, and feeling. Adaptations to the instrument focused on the administration of the think aloud. Evaluators prompted the guest to verbalize their thoughts repeatedly, which resulted in the evaluator taking the role of facilitator. Rather than enforcing a clear delineation between evaluator and facilitator, PacSci evaluators chose to embrace the facilitation role. The Tinker Tank project team discussed and adapted the protocol after analysis of the data.

Interactive Multiple-Choice Survey	Tinker Tank's Cardboard City activity; 2019 Seattle Design Festival; Greg Kono, Tinker Tank Specialist	Conversations with Tinker Tank staff led to an interest in developing an interactive data collection instrument. Inspired by a Tinker Tank facilitated activity and with guidance from Greg Kono, PacSci's Evaluation team developed an interactive multiple-choice survey using a peg board and posing questions intended to assess aspects of motivation, identity, and community among Tinker Tank participants. A pegboard, where guests could wrap yarn around pegs to indicate responses to questions (similar to multiple-choice questionnaires with the option to select more than one answer for a question), could provide a strong starting point for the development of the tool. Adaptations included upsizing the peg board to both attract audiences and to space the questions and answers. The final iteration of the interactive multiple-choice survey utilized a larger and heavier piece of the pegboard. Further refinement included securing the pegs with hot-glue, color-coding and laminating labels, staggering pegs, and providing minimal instructions with colorful yarn for Tinker Tank participants to respond

Methodology

In year one (2019) of the IMLS grant, PacSci's evaluation team assessed Tinker Tank's makerspace with a mixed-methods approach. This mixed-methods approach gathered data from Tinker Tank guests through observations (VEF and DoLF), conversations (interviews and think alouds), and an opt-in interactive multiple-choice survey. Guests included children (under 18 years old), adults (over 18 years old), and caregivers.

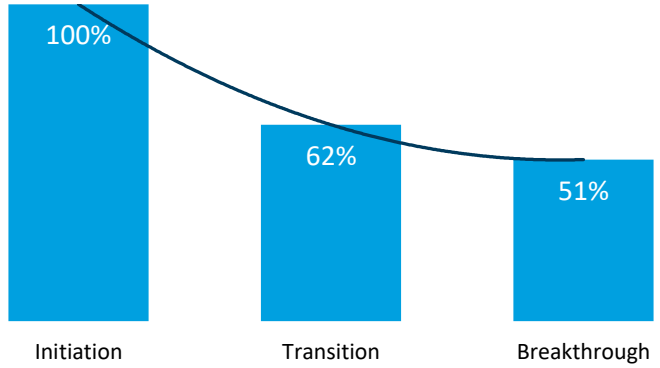
Sampling		
Instrument	Administration	Response
Visitor Engagement Framework (VEF)	Observations conducted on every third guest who engaged with a Tinker Tank facilitated activity. Random sampling.	108 observations
Interviews	Administered after guest finished interacting with a Tinker Tank facilitated activity. Opportunistic sampling.	367 interviews
Dimensions of Learning Framework (DoLF)	Observations conducted on every third guest who engaged with a Tinker Tank facilitated activity. Random sampling.	69 observations
Think Alouds	Administered to every other guest who engaged with a Tinker Tank facilitated activity. Random sampling.	12 think alouds
Interactive Multiple-Choice Survey	Guest opt-in. No sampling protocol implemented.	100 responses

Findings

Visitor Engagement Framework (VEF)

Observations of guest behavior in the Tinker Tank's facilitated activity space were conducted for several activities, allowing for comparisons between them. Forty-eight guests were observed participating in Tinkering with Bridges, 18 in Rockets, 17 in Hootitat, 14 in Up in the Air, seven in Building Circuits, and four in Wind Turbines. Guests who were observed all displayed at least one initiation behavior, engaging with the activity, in order for the evaluator to observe them formally. After this initial engagement, 62% of guests observed for all activities would then display Transition behaviors, representing a deeper level of engagement and learning. The most in-depth and deep learning happened at the Breakthrough level, and 51% of all observed guests who engaged with facilitated activities reached this stage.

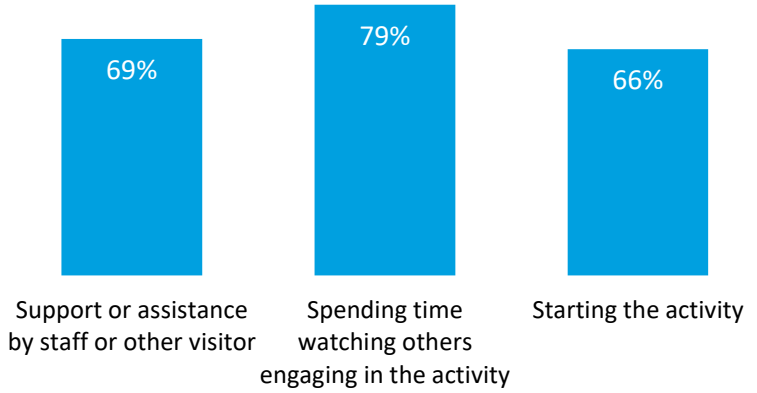
Over half of participants who engaged with a Tinker Tank facilitated activity displayed a *Breakthrough* behavior. (n=108)



Initiation Behaviors

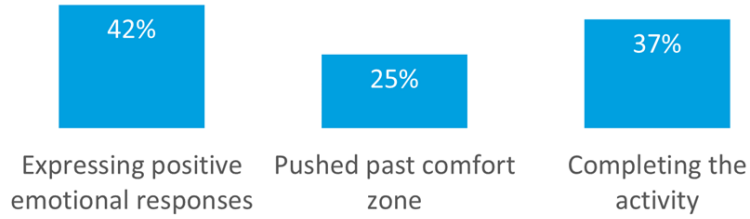
Initiation behaviors represent that first stage of engagement and learning. Guests are drawn in to explore materials, ask questions about what is happening in the space, or begin developing an idea of what they wish to make. They try out examples of projects, watch other guests build and test their creations, and begin work on their own project. The most common Initiation behavior observed was watching others make and test, or explore existing projects. This second most common initiation behavior observed of guests was asking questions of the staff and volunteers in the space, or the other members of their group. This would lead to the guest starting their own project.

Three-fourths of guests spent time watching others engage in the activity prior to starting their own activity or facilitating the activity for a group member.



Transition Behaviors

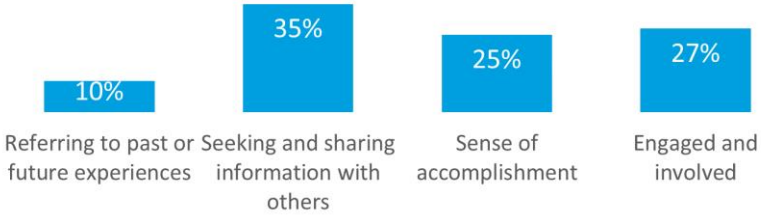
One-third of Tinker Tank participants completed the facilitated activity.



Transition behaviors represent a deepening of engagement that often, but not always, proceeds from Initiation-level behavior. Transition behaviors can take the form of actions like expressing a positive emotional response to the activity, being pushed past one's comfort zone, and completing the activity to the stage of being able to test a finished project. Expressing positive emotional responses was the most commonly observed transition behavior in Tinker Tank. Guests were heard expressing excitement over the materials, displaying investment in their project's design or success, expressing reluctance to leave the activity, and becoming excited over the prospect and outcome of testing their finished creation. One-third (37%) completed their projects to the stage of testing them, though not all of those continued to tinker after an initial round of testing (a Breakthrough behavior). It was uncommon to observe a guest being pushed outside of their comfort zone. When they were, it took the form of expressing frustration over not knowing how to solve a problem, giving up on a particular project in favor of doing another activity, or voicing doubt and uncertainty about an idea or test outcome. However, discomfort and feelings of being pushed past one's comfort zone are not always expressed in ways that are easily identifiable to an observer.

Breakthrough Behaviors

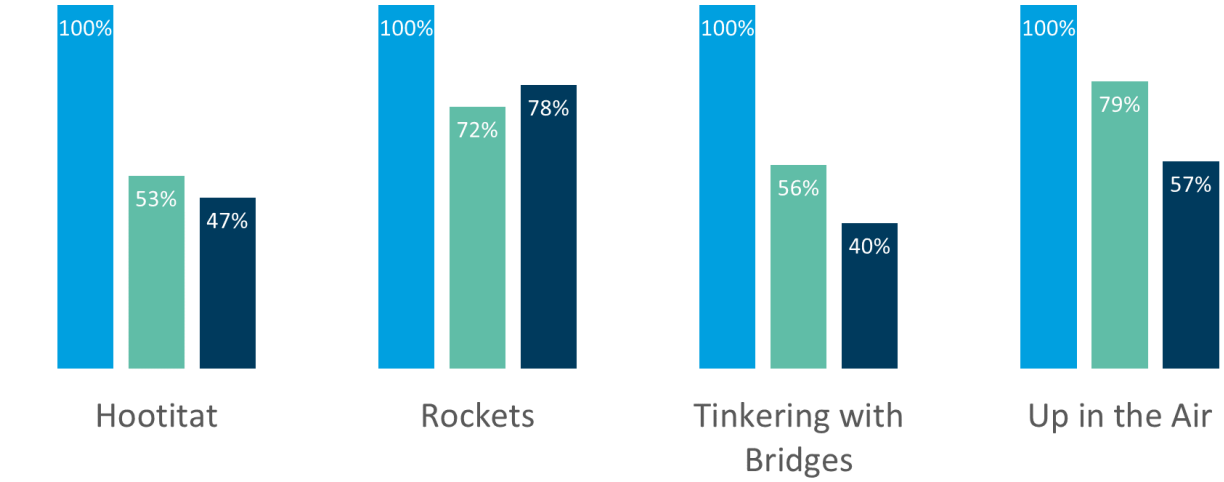
Of the Breakthrough behaviors, one-third of guests sought and shared information with group members, volunteers, and/or Tinker Tank staff.



Breakthrough behaviors represent the deepest level of engagement. Breakthrough behavior are often expressed verbally in conversation, such as a guest making a comparison between the type of bridge they chose to build with k'nex and a bridge they saw in a documentary. Seeking and sharing information with others was the most common breakthrough behavior. Examples of this is guests collaborating to solve a problem or sharing a construction strategy for a rocket nose cone that had survived testing. Another common behavior was guests being engaged and involved, taking the form of iterating upon a project. If a guest tested a rocket several times, each time modifying the fins or the nose cone, that represented being visibly engaged and involved with the activity. Another Breakthrough behavior was displaying a sense of accomplishment. This often occurred when a project was tested successfully with the guest also stopping at various stages of construction to show off their project to group members, volunteers, and/or staff members. This also included if the participant requested a group member film the test of their finished project or photograph their creation.

Stages of Engagement

Rockets and Up in the Air had the most Transition and Breakthrough behaviors observed.

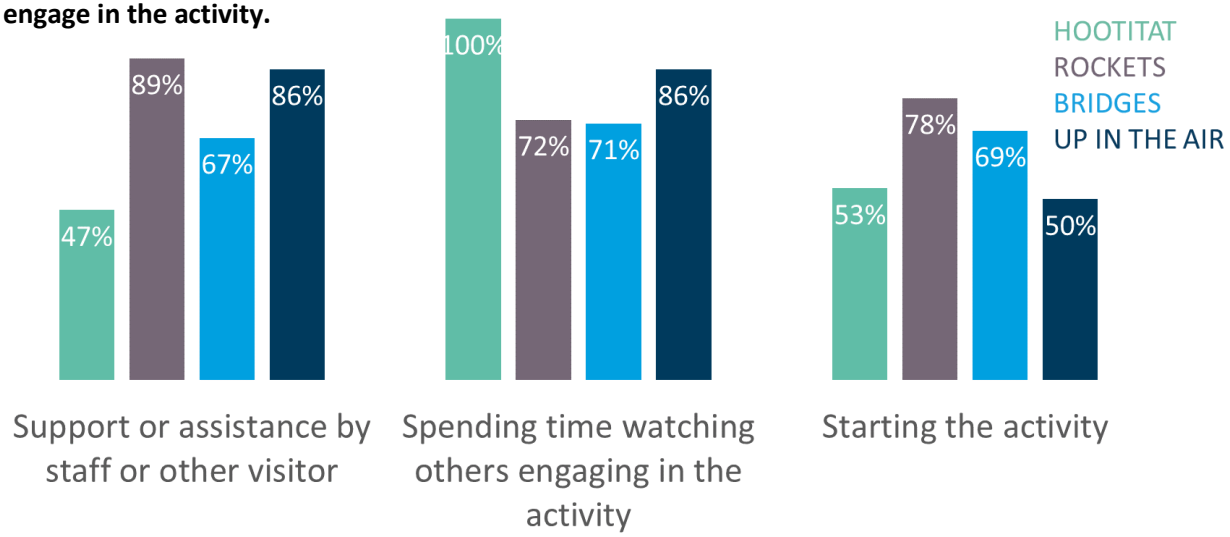


The number of guests observed who reached the stages of engagement after Initiation varied from activity to activity. The behaviors in the Visitor Engagement Framework don't always occur in order from Initiation, to Transition, to Breakthrough. It isn't uncommon to see guests skip from Initiation to Breakthrough stages, without displaying Transition behaviors in between, or for guests to jump from a Transition behavior, back to Initiation, and then to Breakthrough. Some of the activities seem to encourage specific behaviors in guests. Rockets is an activity that is a good example of this. Nearly three-fourths (72%) of guests displayed Transition behaviors, while 78% displayed Breakthrough behaviors. The testing component of Rockets is visible and exciting for guests, who get to launch the paper rockets with air pressure created with a bicycle pump. Creating and testing a paper rocket is accessible for multiple age groups, and the drama and competition of the testing component encourage guests to participate in it, completing their project. Since the test is so dramatic, it often provokes a sense of accomplishment when a rocket succeeds. A guest may test a rocket again, while asking for it to be filmed, to show off the distance the rocket reached. If a test does not succeed, the fun and excitement of the testing will still encourage guests to repair and iterate upon their rocket design to try again, rather than abandoning the project.

Initiation Behaviors - Looking Deeper

Comparing different activities in order to identify common learning behaviors, and how these differ from activity to activity can reveal how different activities promote different forms of engagement. The figure below breaks down observed learning behaviors by activity. 100% of all guests who participated in Hootitat displayed an Initiation behavior by spending time watching others engage in the activity, although half (53%) started a project themselves. This may be because of the way the facilitated activity space is set up for this activity. The testing area for Hootitat is at the front of the space, as is a table full of examples of projects made by other guests. Guests were often drawn to the testing, which was fairly dramatic and visually interesting, or to explore the examples created by others. Often guests would test an example made by someone else, but not necessarily create their own owl house to test, as well. Up in the Air, an activity where guests create and test airfoils with a fan, also had a table for testing as well as examples of already created airfoils. This meant that guests were initially drawn to those things, as they had been with Hootitat. Eighty-six percent of guests spent time watching others engage in the activity, the same percentage (86%) discussed the activity and/or asked questions about it of other guests, volunteers, and/or staff members overseeing the testing. Half of guests (50%) began an airfoil project. Rockets, which also has a dramatic testing component, had thee-fourth (72%) of guests observed spend time watching others engage in the activity, whereas 78% of all guests who displayed Initiation behavior began a rocket of their own. They were also likely to engage with staff or other guests about the activity. This may be because, when the space is busy, staff and volunteers prepare a set of materials on a tray for each guest to take to the table, which sparks the beginning of an engagement where volunteers can introduce Rockets, and guests can ask questions about the activity or the space. Building Bridges shows a fairly even spread of Initiation behaviors, with 67% engaging with the support or assistance of staff, volunteers, or other guests, 71% spending time watching others engage, and 69% beginning the activity.

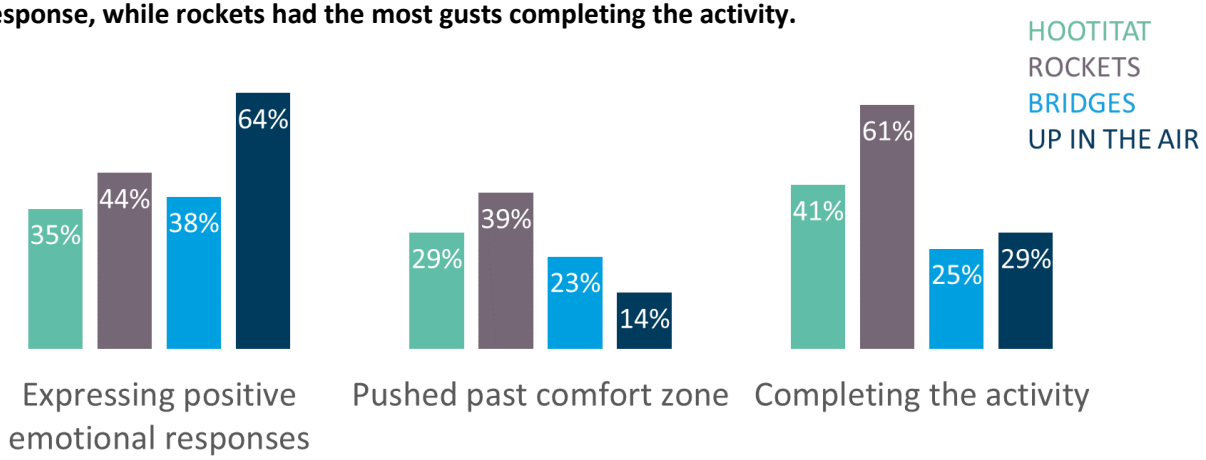
Initiation behaviors varied depending on Tinker Tank facilitated activity. Rockets had more guests starting an activity, while Hootitat had more guests spending time watching others engage in the activity.



Transition Behaviors -Looking Deeper

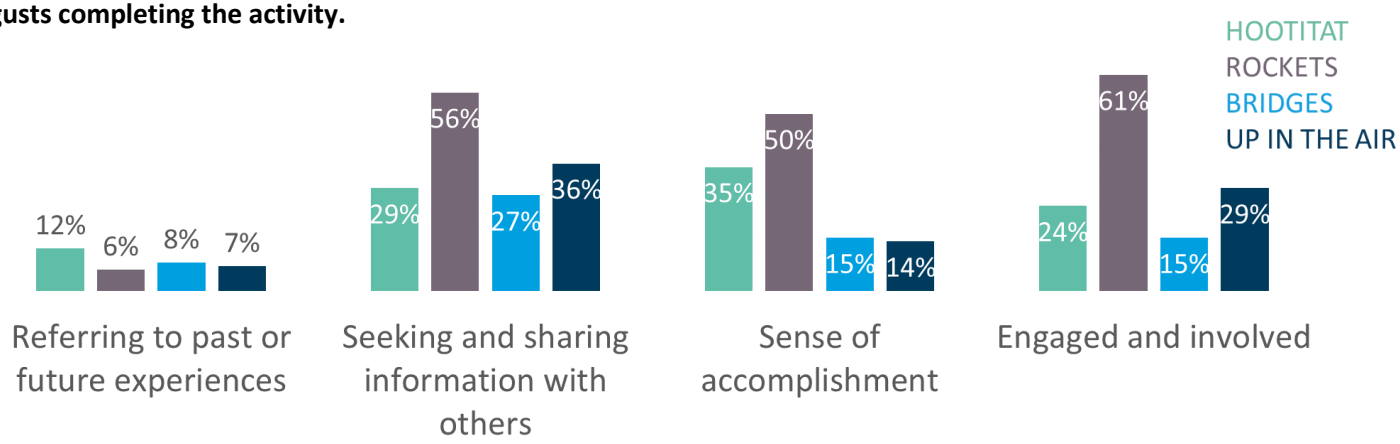
When examining Transition behaviors, we can see that guests were most likely to complete their project to the stage of testing it at least once with Rockets (61%) and Hootitat (41%). These both have fairly dramatic tests that guests start themselves (by turning on the fan for Hootitat, and by pumping air and pressing a button to launch their creation for Rockets). However, Up in the Air also had a similar test to this iteration of Hootitat, involving testing the creation with a fan. Less than one-third (29%) of guests completed and tested an airfoil of their own. One-fourth (25%) of guests completed and tested a bridge using a series of weights. It is possible that many participants in this activity set their goal at completing a bridge and were not drawn to testing it. Over one-third (38%) of participants in Building Bridges expressed a positive emotional response to the activity, displaying excitement over the materials, interest in the project, and investment in what they were making. Up in the Air produced positive emotional response in guests (61%), who were surprised and excited at seeing the example airfoils respond when the fan at the demo table was turned on. Rockets also produced observable positive emotion in participants (44%); even failed tests provoked excitement and eagerness to try again. Rockets also produced a great deal of observable frustration and evidence of guests being pushed past their comfort zones (39%). Guests were invested in reaching the stage of testing a rocket and in seeing it succeed, so they were more likely to push themselves and struggle with materials and construction, rather than simply abandoning the project in favor of something easier. They sought help from group members, instead. Hootitat also showed a similar pattern, with a high rate of completing to testing accompanied by a reasonably high response of frustration and pushing through uncertainty and discomfort.

Transition behaviors varied depending on Tinker Tank facilitated activity. Across the four activities observed, Up in the Air had the most participants expressing a positive emotional response, while rockets had the most gusts completing the activity.



Breakthrough Behaviors - Looking Deeper

Transition behaviors varied depending on Tinker Tank facilitated activity. Across the four activities observed, Up in the Air had the most participants expressing a positive emotional response, while rockets had the most gusts completing the activity.



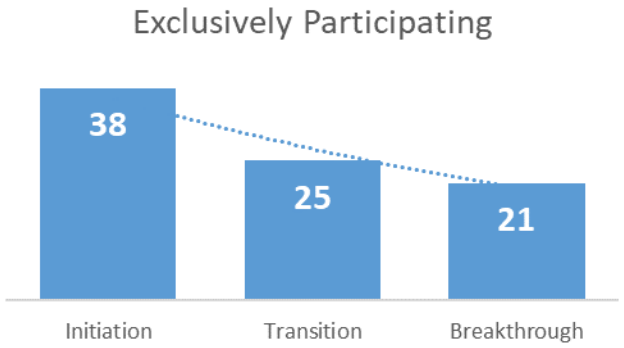
Breakthrough behaviors, as described by the VEF, are generally observed through conversational content between group members. Solo guests are fairly rare in Tinker Tank, so it is often possible to hear a great deal of in-depth discussio in which participants reflect on what they are building. As mentioned earlier, participants in the Rockets activity displayed high percentages of breakthrough behaviors, particularly seeking and sharing information with others, displaying a sense of accomplishment, and being engaged and involved through iteration and repeated testing. The nature of the testing component in Rockets being exciting and hands-on seemed to promote this last, and guests were excited and proud of successful tests, since the results were so visible and dramatic. There was a lot of teamwork and collaboration between group members, as well. A lot of the failure points for the rockets were similar, such as the nose cone breaking off of the rocket's fuselage during an attempted launch, so guests would share strategies or ask for help to combat this, and other shared problems. Referring to past or future experiences while working on a project was the most uncommon of the breakthrough behaviors. It was fairly uncommon for guests to connect what they were making to things they had seen in the world outside of Tinker Tank, or even to past experiences at Tinker Tank, though referring to past making, whether at home or at the science center, was still a common manifestation of this category of behavior. Sense of accomplishment was occasionally difficult to distinguish from displays of positive emotions for some of the activities. In contrast Up in the Air had the highest percentage of positive emotional responses (61%) and the lowest level of expression of a sense of accomplishment (14%).

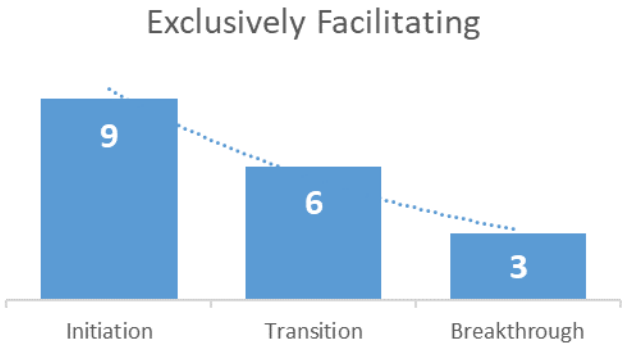
Observable Learning Behaviors and Facilitation vs. Participation

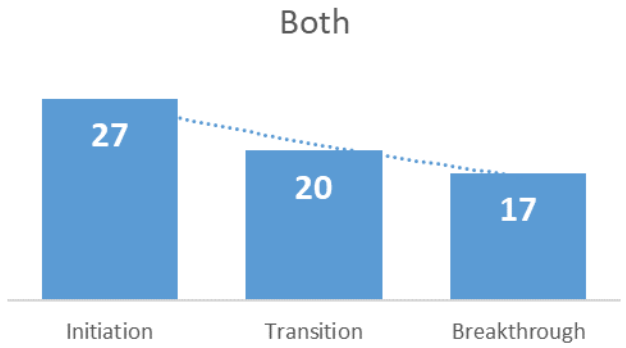
Of the observations conducted using the Visitor Engagement Framework, 74 noted whether the person observed participated in making, facilitating for others, or both. Of those 74, nine people exclusively facilitated the activity for others, 38 people exclusively facilitated, and 27 people both participated and facilitated.

Everyone who was observed displayed at least one Initiation behavior. However, when looking at the jump to displaying Transition level behaviors, those exclusively participating in making a project displayed the lowest percentage of Transition behaviors (65%). Those exclusively facilitating had a slightly higher percentage of Transition behaviors (67%). It was those who both participated and facilitated who showed the highest percentage (74%).

When levels of Breakthrough behaviors are examined for each category of guest observed, there was a drop-off for those who exclusively facilitated for others. One-third (33%) of those exclusively facilitating displayed Breakthrough behaviors. Of those who exclusively participated in making a project, 55% displayed Breakthrough behaviors. Of those who both participated in making a project, and helping facilitate the experience for others, 63% displayed Breakthrough-level learning behaviors.







Interviews

Across numerous iterations of the One-hundred and seventy-two interviews were conducted with guests after they engaged with a Tinker Tank facilitated activity. The interview came out of a gap in the VEF and interest in understanding frustration or being outside of one's comfort level. It should be noted, the two instruments (VEF and interviews) were not conducted during the same period of time, or with the same guests, as the interview was utilized after we had finished collecting data using the VEF.

Comparison between Frustration Observed and Reported in Interviews

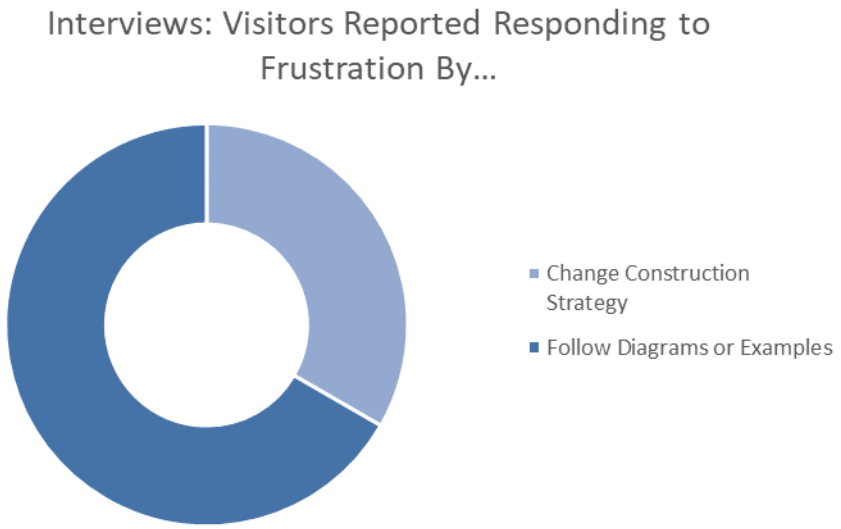
The first notable difference is that more frustration was observed during VEF data collection than was self-described by guests in interviews. During data collection using the VEF, five of the 17 people (29%) observed demonstrated frustration during Hootitat and seven of the 18 (39%) people observed demonstrated frustration during Rockets. Guests during these particular interviews were asked whether they felt pushed outside of their comfort zone, which the adapted VEF had linked to the behavioral indicator of expressions of frustration. It must be acknowledged that guests may have framed their experience differently than evaluators observing them might have. During data collection using interviews, one guest expressed that they had felt pushed outside of their comfort zone while participating in Hootitat, out of the 11 interviewed. Four people who participated in Rockets, out of the 18 interviewed, responded that they had felt pushed outside of their comfort zones. This could be indicative of a number of things. Perhaps guests observed displaying frustration while the VEF was in use had a certain expectation of, and comfort with, failure and frustration as elements of the tinkering process, so they did not feel pushed outside of their comfort zones, despite become frustrated by the tasks. It is also possible that the opposite is true, and that guests interviewed did not want to self-describe what they experienced as being pushed outside of their comfort zones, due to a perceived negative connotation of struggle and failure as part of the process.

In both interviews and VEF observations, the most common occurrence leading up to incidences of frustration or feeling pushed outside of a comfort zone was difficulty with the construction of a project. In interviews, the second-most common responses were difficulty with design, general uncertainty about how to approach the task, issues with materials, and the failure of a project during a test. In each case, one interview respondent cited this as what had happened to make them feel pushed outside of their comfort zone. In the VEF observations, the second most common actions related to the incidence of frustration, and perhaps inciting it, was failure during testing. The third most common was difficulty with the design of a project. The fourth most common was difficulty related to the developmental skill-level of the participant (for example, a young child struggling to use a hole-puncher). However, this was not a cause of feeling pushed outside of a comfort zone that was reported in any of the interviews.

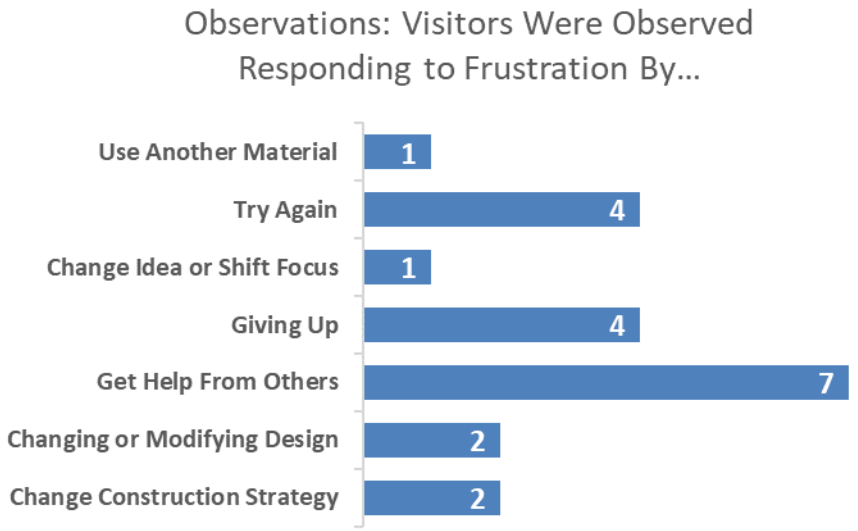
Observed vs. Self-Reported Frustration

Along with measuring the feeling of frustration and pushed outside their comfort zone, analyses analysis measured subsequent actions or thoughts. Of the four guests interviewed who had said they had felt pushed outside of their comfort zone while working on making rockets, two were willing to provide specific answers to the follow up question, asking what they had done next.

The most common response to feeling pushed outside of their comfort zone was for guests to look to examples or diagrams in the facilitated activity space, and use those to try to spark ideas for how to address challenges. The other response by an interviewed guest who felt pushed outside of their comfort zone was to change their strategy for constructing their project, to see if another method might solve their difficulty.



The most common response following an observable expression of frustration was to ask for help, usually from a group member, but sometimes from staff members or volunteers in the space. The second most common responses were to either try whatever the guest had been doing a second time, or to give up. Giving up might mean abandoning the facilitated activity entirely, but it also might be starting the project over from scratch, and continuing to try to make it successfully by starting with a new idea. The third most commonly observed follow-on actions were to change or modify the design of what was being built, or to try a different strategy for putting it together.



Why Guests Wanted to Do This Again

Out of 367 interviews, 96% guests said that yes, they would like to do something similar again in the future. Seven guests said that no, they would not like to do so and 17 guests said that they weren't sure or maybe. When asked to explain, respondents provided a variety of reasons.

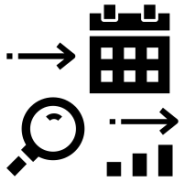
For anyone under the age of 18, enjoyment of the activity was the primary motivator for wanting to do a similar activity in the future. As you can see in the additional figure below, that enjoyment most often came from the act of making or tinkering itself, or from the specific nature of the facilitated activity that they had participated in. Five to eight year olds also enjoyed their success in completing and testing projects, being pleased with the finished products that they had created. Nine to 12 year olds enjoyed the challenging aspects of the projects, how it reminded them of a puzzle and that they might have to try multiple things before it worked. They also enjoyed the element of competition, whether that was against group members or against themselves. Adults also enjoyed the creative aspects of tinkering.

Beyond enjoyment of the activity, or having fun while doing the activity (also a common response), the variety of materials available and the testing process appealed strongly to five to eight year olds. Nine to 12 year olds also commonly cited testing their projects as being part of what was appealing about doing similar activities in the future. They were also likely to mention an interest in STEM topics, or the open-ended nature of Tinker Tank projects as being compelling to them.

For the majority of adults interviewed, children were what compelled them to want to do a similar activity again. These responses about kids broke into two categories, as you can see in the additional figure below. Adults would refer to wanting to keep children in their group entertained, or wanting to encourage the children's learning (or both). Adults who were motivated by keeping their kids entertained said they wanted to find a way to keep their child occupied, mentioned that Tinker Tank is their child's favorite place to visit, or they mentioned a child loving a particular topic or material that relates to the activity. Adults who were motivated by encouraging their children to learn mentioned developing specific skills such as problem-solving or fine motor skills, mentioned homeschooling or schoolwork addressing similar topics, or they had a desire to encourage their child to engage more with STEM topics. Of the 41 adults who gave responses related to kids, 21 mentioned something connected to keeping children entertained, and 20 gave responses related to encouraging the children to learn. Enjoyment of the activity, and having fun, are the next two most common responses from adults, falling back into the pattern seen in other age groups. Adults were also more likely to mention social aspects of the activity as being their motivator, such as teamwork, or spending time together as a family. Investment in doing similar activities over time was also mentioned: adults were more likely to refer to feeling invested in visiting Tinker Tank regularly, or doing STEM-related activities often over time as being valuable to them.

Why I Want to Do This Again, by Age Group

	Age Group: 0-4	Age Group: 5-8	Age Group: 9-12	Age Group: 13-17	Age Group: 18+
Enjoyment	3	61	54	4	34
Kids	0	2	0	0	48
Fun	3	38	24	1	25
Testing	0	22	10	0	3
Social Component	0	1	4	0	13
Personal Learning	1	2	5	0	12
Repeat Engagement or Long Term Investment	1	6	5	0	10
Materials Available	2	9	5	2	7
Interest in STEM	0	6	9	0	6
Misc.	1	9	1	0	0
Skill Development	0	0	0	0	8
Open-Ended (Freedom to Determine Design, Method, End-Product)	0	1	8	1	7
Cool/Neat/Interesting	0	7	4	2	5
Novelty	0	2	4	0	6
Hands-On	0	1	2	0	4
Interest in Arts and Crafts	0	2	1	0	4
Identity	0	2	2	0	0
Taking Project Home	1	2	2	0	1
I Don’t Know	0	1	2	0	1

Why Do You Want to Do Something Like This Again?	n*	Examples
 Fun	91	“Doing stuff like this is fun.” “It's fun to make new things that help me learn about how things that I see in the world every day work.” “It's fun. You get to try new stuff. Sometimes I do it at school.” “Using the tape was fun.”
 Testing	35	“It's really fun to get your animal moving; it's like making something come to life.” “Testing it; I like the shaking part.” “I like throwing it to see how far it goes.”
 Materials Available	25	“I like all the stuff I can use to make things here.” “I like all the colors (of paper).” “There's a lot of stuff that you can use.” “The materials. The pipe cleaners.”
 Repeat Engagement or Long Term Investment	22	“It's like an activity with the girl scouts that she likes. She can spend like two hours doing this!” “She and I do a lot of activities like this at home. We do a lot of Kiwi Co Cube Crates.” “We like Tinker Tank very much.”
 Interest in STEM	21	“I like electrical stuff.” “I like coding.” “I like tinkering with circuits. I like how batteries work.”

	Personal Learning	20	“I hadn't understood hydraulics before. Seeing the examples at the table really helped me get the concept of the physics of it.” “We get to build and problem-solve; it teaches about balance, and a bit of engineering.” “It makes you think.”
	Social Component	18	“It's fun to do this, as a family.” “It's pink! I liked working together and launching it into the wall. The nose crunched!” “It's fun, and you can do teamwork, if you want to.”
	Cool/Neat/Interesting	18	“It's interesting, because it's dynamic, and you can control it (the movement).” “I want to make another flying thing tomorrow! Because it can fly, and it looks cool!” “Because it looks cool!”
	Open-Ended (Freedom to Determine Design, Method, End-Product)	17	“I like that I can do anything with this (create any kind of moving figure).” “I like the freedom to be able to make something without following a pattern.” “There's endless possibilities. You can be creative, and make anything.” “It's tactile, analog, free-form, spontaneous. It's like jazz, you make it up as you go along.”
	Novelty	12	“It's fun to make a game that I haven't seen before.” “He spends more time in the Tinker Tank working on projects than on the other stuff, in a visit, because the Tinker Tank project changes, but the exhibits stay the same.” “We're bored with most stuff now, since we've been coming here for years. This is where he spends most of his time.”
	Misc.	11	“I just like it.” “It's automatic. The whole system's automatic.” “You can get it done in a set amount of time.” “I like making a rainbow.”

	Skill Development	8	“Every time we've come here, she has tried to build something, but she's never finished anything. She always gets engaged, and can do something, though, even if it's just finding paper, or helping out, or investigating the tools.” “You have to be very patient.” “I could probably do it better next time.”
	Hands-On	7	“It's nice to do, not just observe. Interacting is better.” “I like pulling on levers to make things move.” “There's freedom for the kids to interactively do this. I wish the dinosaur exhibit was interactive like this; they'd love that.”
	Interest in Arts and Crafts	7	“I like crafting.” “I love arts and crafts.”
	Taking Project Home	6	“We're gonna bring them home!” “I get to keep it.”
	Identity	4	“I'm a tinkerer; I love activities like this one.” “I like to see how wind can affect things. I'd like to be a windmill engineer.” “I want to be an inventor.”
	I Don’t Know	4	“I don't know.” “I just don't know.”

*Number of participants who mentioned something that related to that theme.

Responses About Kids, by Age Group:

	Age Group: 0-4	Age Group: 5-8	Age Group: 9-12	Age Group: 13-17	Age Group: 18+
Keeping Kids Entertained	0	1	0	0	21
Encouraging Kids' Learning	0	1	0	0	20

Types of Responses About Kids	n*	Examples
 Keeping Kids Entertained	22	"Not so much for myself, but it's fun. The kids have fun with it." "It burns off his energy." "He likes to try the different activities. He can spend an hour here, easily! We come here every weekend."
 Encouraging Kids' Learning	21	"It's a good opportunity for him to learn, and for him to get familiar with stuff like this, before he sees it in classes. He'll be comfortable with it." "It can be a means to teach kids." "Because we're here to teach him how to manipulate objects and solve problems."

*Number of participants who mentioned something that related to that theme.

Responses About Enjoyment, by Age Group:

	Age Group: 0-4	Age Group: 5-8	Age Group: 9-12	Age Group: 13-17	Age Group: 18+
Enjoyment of Making or Tinkering	1	25	19	1	13
Enjoyment of Challenge	0	3	16	0	8
Enjoyment of Specific TT Project or Activity	2	15	16	0	5
Enjoyment of Success	0	13	7	1	4
Enjoyment of Creativity	0	7	5	1	12
Enjoyment of Invention	0	5	5	1	1

Types of Responses About Enjoyment	n*	Examples
 Enjoyment of Making or Tinkering	59	“Because I like building and making things.” “I just enjoy tinkering.” “I like building things, in general.” “It's fun to use items to create something new.”
 Enjoyment of Specific TT Project or Activity	38	“It's fun. I liked the rockets!” “I just like making funny animals like this.” “It's fun. I like how you get to show animals, and also make them turn.” “It's fun being able to get the computer to do interesting designs.” “It's cool to see a robot create something you want on a chromebook or tablet so that you can show it to other people and they can see your design.” “I especially liked the flapping mobiles; I made a toaster.”
 Enjoyment of Challenge	27	“I like making this. It's hard, because I have to make it move, but I think I can do it.” “It's like a puzzle.” “It's fun to create things, figure out what works and doesn't, and learn from your mistakes.” “I like to try new things, even if they seem impossible at the moment.” “I like how, if you fail, you have to persevere and start over again. You have to try more than once, because it won't turn out right, right away.”
 Enjoyment of Success	25	“It wasn't discouraging.” “I like to make cool things happen at the flip of a switch.” “It's easy to do this!” “It's fun launching it, and having that feeling of ‘Yes! It worked!’”

	Enjoyment of Creativity	25	"It's fun to be creative and try creative things." "It's a chance to get your creativity out!" "We like tinkering with different materials, seeing how they mix, realizing what's in our imaginations." "It's creative, and you can use your imagination."
	Enjoyment of Invention	12	"Because making things is so cool. You can make something no one has made before." "I think it would be fun to try a new idea. If I couldn't get to it, today, I could try it on another day." "It's really inventive."

*Number of participants who mentioned something that related to that theme.

Guests Who Did Not Want to Do This Again

A small number of guests said they did not want to do a similar activity again. Reasons why they did not want to do a similar activity included wanting to do a different activity (n=4). When asked to elaborate, guests would mention another favorite Tinker Tank activity that they had done in the past, or something they'd done at home that they'd enjoyed more. Adults who answered that they didn't want to do this again most often said that that was either because they felt it was too advanced for the age and developmental level of their child, or because they felt uncomfortable that the activity lacked the structure of precise instructions.

Why I Don't Want to Do an Activity Like This Again, by Age Group

	Age Group: 0-4	**Age Group: 5-8**	**Age Group: 9-12**	**Age Group: 13-17**	**Age Group: 18+**
Want To Do A Different Activity	0	1	3	0	0
Too Difficult	0	1	1	0	0
Uncomfortable With Lack of Structure	0	0	0	0	1
Age of Caregiver's Child	0	0	0	0	1

Why I Don't Want to Do Something Like This Again?		n*	Examples
	Want To Do A Different Activity	4	"I like the snap circuits better." "I liked the stuff with the goggles better (VR activities in What is Reality)."
	Too Difficult	2	"Not sure, but maybe not. It was hard to make the inside part. I'm still trying to fix it. It's a hard project; I'd want to do something else, instead." "The nose cone is hard, and there's other stuff that's hard."
	Uncomfortable With Lack of Structure	1	"I like following the instructions, not inventing. In my job, I implement instructions to create things. I'm more comfortable with that."
	Age of Caregiver's Child	1	"It's too hard to get him to stay still for long enough. Maybe when he's older."

*Number of participants who mentioned something that related to that theme.

Where Have You Done an Activity Like This In the Past?

Two-hundred and fifty-nine guests were asked if they had done a similar activity in the past. Ninety-eight respondents said that they had not done anything like this before that day. One-hundred and fifty-seven guests said that they had done a similar activity, with 138 of those elaborating on where and what that similar activity had been. Four responded that they didn't know if they'd done something similar, or that maybe they had but weren't sure.

In the figure below, responses to where guests had participated in a similar activity are broken down by age group. As before, there were few respondents in the age categories of 0-4 and 13-17. For Four year olds and younger, their similar experiences had occurred either in past visits to the Tinker Tank, or in school settings, such as preschool. Teenagers (13-17 year olds) also responded that their similar experiences had been in one of those two settings (Pacific Science Center or school), but they were more likely to have done something similar in school, rather than at Pacific Science Center.

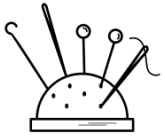
The most common place that five to eight year olds had done something similar was on prior visits to Pacific Science Center. The second most common place that they had done something similar was at home. The third most common response was that they had done something similar in a school context. Nine to twelve year olds were most likely to have done a similar activity at school. Their second most common response was that they had done something similar on a past visit to Pacific Science Center. Their third most common response was that they had done something similar at home.

Like five to eight year olds, adults were also most likely to respond that they had done an activity like this on a past visit to Pacific Science Center, and second most likely to respond that they had done a similar activity at home. Some recalled similar experience from their school days as well. Adults were the only group to have done something similar in a workplace. Five to eight year olds were the only age group to include participants who had done a similar activity in a library setting.

Where Guests Have Done An Activity Like This Before, by Age Group

	Age Group: 0-4	Age Group: 5-8	Age Group: 9-12	Age Group: 13-17	Age Group: 18+
At Pacific Science Center	1	20	18	1	15
At School	1	9	20	2	4
At Home	0	13	6	0	11
At Another Museum	0	2	6	0	3
Camp or Scouts	0	2	3	0	0
Hobby or Craft	0	2	2	0	0
Other Science Event	0	2	1	0	0
Library	0	1	0	0	0
Work	0	0	0	0	1

Where Have You Done an Activity Like This Before?	n*	Examples
 At Pacific Science Center	253	“In Tinker Tank, three days ago. I built a different boat.” “I did another one (Tinker Tank project) with the ducks in it. I can't remember what it was.” “I've done this one before, and the car, and the flapping animals, at Tinker Tank.” “We've built other things at Tinker Tank. We built bridges.” “We were at Tinker Tank yesterday, and made one. Today, he woke up, and wanted to make another rocket.”
 At School	158	“At school, I used Scratch.” “At school. I used scratch, and made a ping pong game, and a game where you are a ghost and you are trying to avoid flashlight beams that get faster and faster.” “In school. We made boats with sails, and blew them across a table with the fan from the gym.” “At school, we made boats from straws and plastic wrap. They had to be able to carry one hundred pennies, and we weren't allowed to use tape!”
 At Home	133	“The same thing, but making vehicles go across sand. I did it at home.” “When I was a kid, I built a boat once, and built cars. Usually at home, over the summer.” “I build stuff at home; I made a dollhouse.” “I've built Lego cars at home. Legos are like k'nex, a bit.”
 At Another Museum	42	“At OMSI. We had to make a boat to carry stuff through a course with obstacles.” “A project at a science center. You had to build something and see if it could fly.” “At the Science Center in Connecticut. I built a Lego car, and sent it down a ramp. It was a bit like this, but not quite.”
 Camp or Scouts	22	“Pinewood derby for Scouts.” “I made a paper kite at camp.”

	Hobby or Craft	22	“I do crafting, but haven't done a bouquet.” “I made a radio.”
	Other Science Event	15	“I did an egg drop, while I was on a cruise.” “I made a Bristle Bot, at a Science Fair in Pierce County.”
	Library	5	“I built a boat at the library.”
	Work	5	“I'm a mechanical engineer.”

*Number of participants who mentioned something that related to that theme.

Of the responses in which guests expressed that they had participated in a similar activity in a school setting, some respondents specified whether it was in a classroom setting or project, or whether it was through an extracurricular activity. The former was a much more common response than the latter, especially from children between the ages five to seventeen. 4 year olds and younger as well as adults were more likely to respond that it was an extracurricular activity in a school setting, rather than within the formal classroom.

Responses about School

	Age Group: 0-4	Age Group: 5-8	Age Group: 9-12	Age Group: 13-17	Age Group: 18+
In Class	0	7	17	2	0
Extracurricular	1	1	1	0	1

Responses About School		n*	Examples
	In Class	108	"My second grade class had Tinker Time: the teacher would give us a challenge to make something out of the specific materials she gave us, and we'd build something." "I took a Robotics class." "In kindergarten, we made paper plane projects." "In first grade, we studied space, and made rockets."
	Extracurricular	23	"Daycare activities." "At After-Care, after school, we had k'nex to build with."

*Number of participants who mentioned something that related to that theme.

Guests Describe What They Think About While Working on Projects

One of the last questions added to the interview focused guests' thoughts as they worked on their Tinker Tank projects. Twenty-nine guests were asked this question in interviews. The most common response focused on their goal, whether that included defining that goal or trying to determine how to achieve it. The second most common response that guests were thinking about was an external source of inspiration for their idea. This might be something that they had read about, something they saw another group member working on, or something they had an interest in. The least common response that guests were thinking about as they worked, at least as self-described by those who were interviewed, was the immediate next step in the project as they were building. Guests were more likely to sum up their thoughts as being focused on a bigger picture idea, whether that be a source of inspiration that sparked their idea or their overall goal for their project rather than the procedural steps of building a project.

What Were You Thinking About?	n*	Examples
 Goal/Outcome	12	"I was thinking, 'Will he die?'" (referring to astronaut) "I was thinking about how to get to the moon rock." "I was wondering, 'What is this going to be? Will it turn out well?' because we had to refill the syringe, and added too much water." "I was mainly thinking about how to keep it afloat, and moving forward." "That it should go in the water and hold the duck."
 External Inspiration	11	"A book that I read, about someone with a parachute jumping from a plane safely." "I was thinking about tractors." "I saw my brother's. It looked like a tricycle, so I thought, 'Why don't I build a car?'" "I was thinking about what my friend was making. I got the idea from my friend."
 Next Step in Project	8	"I thought that I should put on smaller wheels, but then it was too close to the ground, and it got stuck." "I was thinking of using a Dixie cup, but decided not to. I thought it wouldn't work." "I was thinking about what to do next for building." "I was just thinking about making it."

*Number of participants who mentioned something that related to that theme (out of a total of 29).

Guests Describe What Problem They Were Trying to Solve

Guests were also asked to describe what problem they were trying to solve with their project. Twenty-nine guests were asked this question. Most guests described the problem they were trying to solve as something built into the activity itself. This might be trying to reach the goal of the activity (trying to get a wind-powered boat to the end of the track, without it sinking, for example) or trying to overcome a difficulty specific to their own experience with the activity (trying to plug up a leak that appeared in the bottom of their boat). Guests would occasionally respond that they weren't trying to solve a problem at all. The least common response was for guests to specify a problem they were trying to solve that was external to the nature of the activity. They were unlikely to connect what they were doing to real-world applications or to longer-term learning and skill development.

What Problem Were You Trying to Solve?	n*	Examples
 A Problem Internal to the Activity	27	"It (the bear) would get too big; it was supposed to enlarge every time it ate a reindeer." "The problem was floating." "I put too much tape on the bottom, so it sunk because of the weight from the water getting in." "Trying to cut a hole in the plastic for the slingshot. The staff member helped me by cutting it with the box cutter." "We needed the water to push the crane arm up." "Lifting ducks. How to lift them." "Getting by the obstacles." "How the grip (on the wheels) could work. I solved it with plastic bands."
 Not Trying to Solve a Problem	2	"I wasn't really trying to solve a problem. It's a game where you have to get the unicorns to play a fun activity together." "I wasn't trying to solve a problem."
 A Problem External to the Activity	1	"Getting him to concentrate!"

*Number of participants who mentioned something that related to that theme (out of a total of 29).

Dimensions of Learning Framework (DoLF)

Guests observed through Dimensions of Learning Framework (DoLF) displayed a variety of learning behaviors while engaging with the facilitated activity in Tinker Tank. The majority of observed guests displayed a behavior from the "Engagement" Learning Dimension, which included guests' interacting with the Tinker Tank facilitated activity (90%) and/or displaying motivation or investment in the activity (61%). The next most frequently observed behaviors came from the "Initiative and Intentionality" Learning Dimension, specifically guests' seeking and responding to inspiration from other guests, facilitator(s), materials, and/or the Tinker Tank environment. Seeking and responding to inspiration also occurred when guests modified or iterated on their design in response to the inspiration they found. The same percentage of guests (38%) also displayed behaviors of seeking and responding to feedback. Feedback occurred through guest prompt (e.g. Child participant asking caregiver for advice or feedback on a current design) and/or received by the guest through unsolicited feedback from peer(s), facilitator(s), materials, or the environment. Seeking and responding to feedback also consisted of guest's anticipating the outcomes of their design or creation and iterating based on those perceptions.

In general, PacSci Evaluators saw less indicators of learning behaviors from the "Development of Understanding" Learning Dimension. "Development of Understanding" consisted of three learning behaviors. These learning behaviors include expressing realization or newly making sense of something (Express realization: 17%), applying prior knowledge or elaborating on current work by engaging in increasingly complicated and sophisticated work (Applies knowledge: 14%), and striving to understand the process or outcome of the activity by testing and retesting their creation or indicated not knowing the outcome yet remaining in the space to explore their confusion (Strives to understand: 10%).

Overall behaviors observed at Tinker Tank's facilitated activity indicate that guests more readily engage in the activity, but are less likely to develop an understanding for the activities approach or outcome. (n=69)

Observable learning behaviors did vary depending on who was (or was not) facilitating the Tinker Tank activity. Facilitators could be Tinker Tank staff, Tinker Tank volunteers, caregivers, as well as educators from other PacSci departments such as Youth & Family Programs (YFP) and Science Interpretation Programs (SIP). Not all participants had a facilitator present. The graphs below vary in sample size to account for participants who did not experience activity facilitation. In contrast, some participants had more than one facilitator.

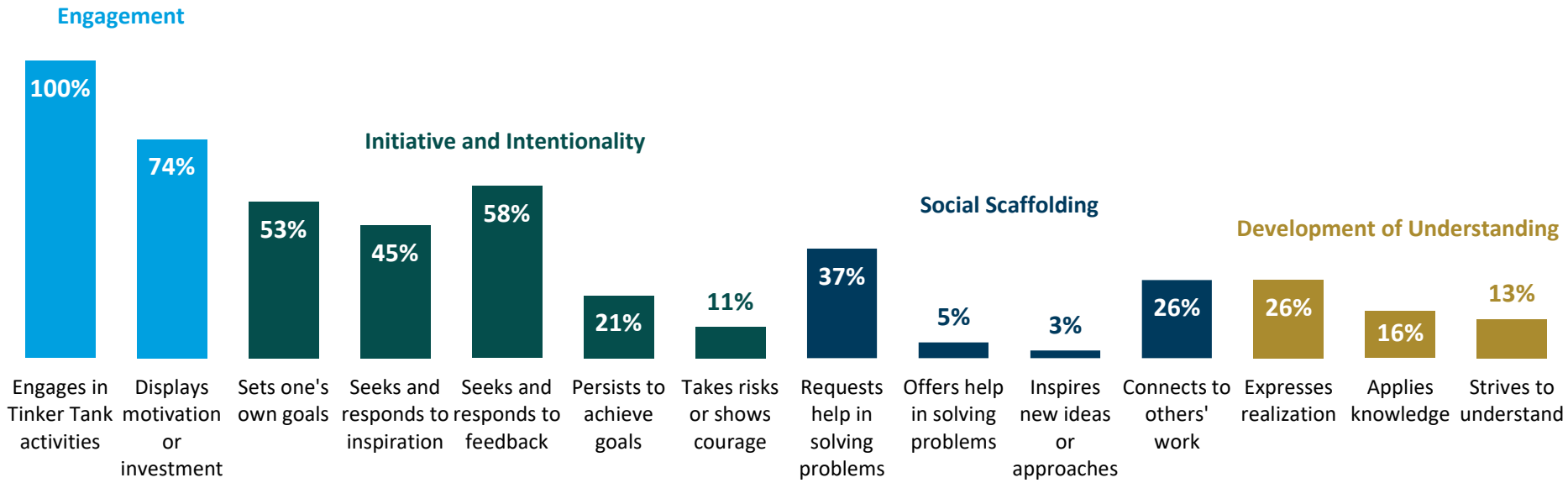
Guests who had Tinker Tank staff facilitators displayed more learning behaviors in two Learning Dimension categories, "Social Scaffolding" and "Development of Understanding." One-third of activity participants expressed behaviors across the four learning behaviors that comprise "Social Scaffolding," This includes requesting help in developing ideas or approaches, requesting tools or materials in service of an idea (33%), as well as the offering help in developing ideas or approaches and offering tools or materials (33%). "Social Scaffolding" also consisted of inspiring new ideas or approaches by talking about other participants' work and innovating by using or modifying other participants' ideas or strategies (33%), as well as connecting to others' works by leaving something of their own work behind to share or produce work that interacts with other participants' work (38%).

When looking at "Development of Understanding," nearly one-third of guests who had Tinker Tank staff facilitation displayed learning behaviors when it came to expressing realization of an approach or outcome (29% of guests) and/or applying prior knowledge or by engaging in work that is more complicated and elaborating on their designs/creations (29%).

Learning behaviors observed among participants who experienced *Tinker Tank staff* facilitation. (n=21)

Guests who experienced facilitation from a caregiver or other PacSci colleagues (Tinker Tank volunteers, YFP staff, & SIP staff) displayed a smaller percentage of learning behaviors when it came to offering help and inspiring new ideas or approaches. In contrast to the guests who received facilitation from Tinker Tank staff, guests who received facilitation from a caregiver expressed more behaviors in the "Initiative and Intentionality" learning category. Specifically, setting one's goals (53%) and seeking and responding to inspiration (45%)

Learning behaviors observed among participants who experienced *caregiver* facilitation. (n=38)



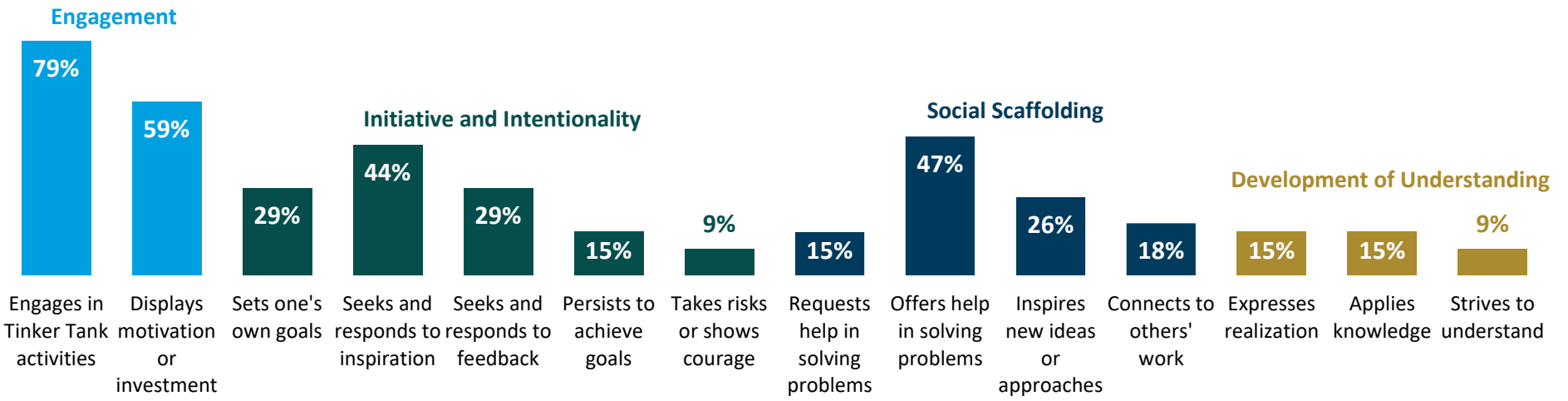
Guests who experienced facilitation from other PacSci colleagues expressed less learning behaviors when it came to seeking and responding to feedback (35%) when compared to guests who received Tinker Tank staff facilitation. Guests who experienced other PacSci facilitation also expressed less learning behaviors when it came to applying knowledge to the activity, idea, or creation (5%)

Learning behaviors observed among participants who experienced facilitation from *SIP staff*, *YFP staff*, and *Tinker Tank volunteers*. (n=20)

Observable learning behaviors differed depending on whether it was a child or adult participating in Tinker Tank activities. Child participants more often displayed behaviors focused on setting goals (40%; adult 29), seeking and responding to feedback (46%; adult 29%), requesting help (31%; adult 15%), connecting to other's work (26%; adult 18%). Adult participants sought and responded to inspiration (44%) than child participants (31%), as well as offer help in solving problems (47%; child 3%).

Learning behaviors observed among participants who are *children*. (n=35)

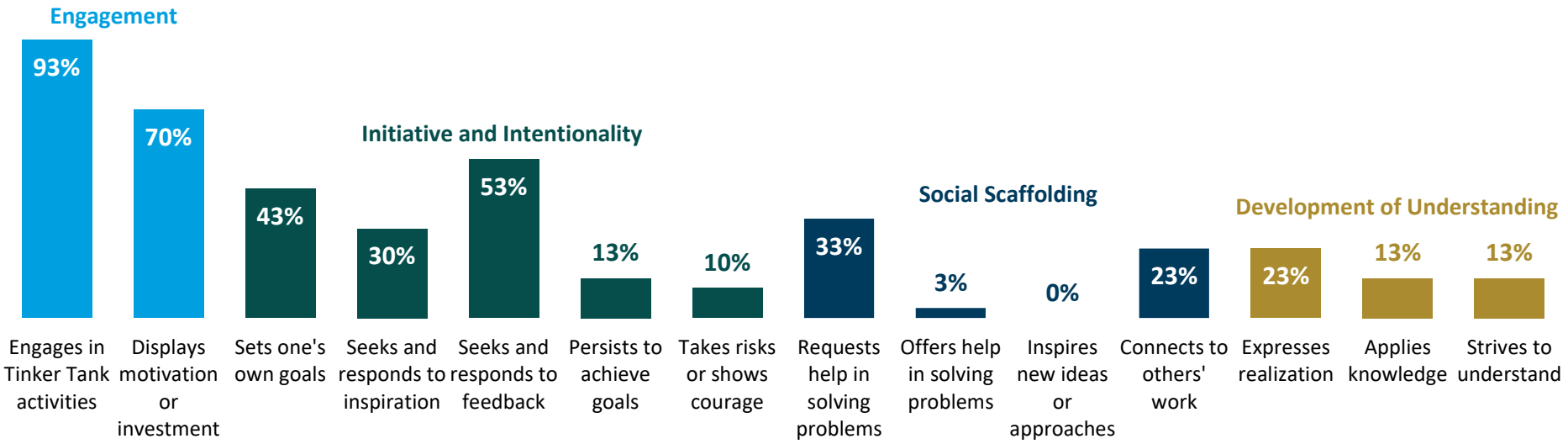
Learning behaviors observed among participants who are *adults*. (n=34)



Children who participated in Tinker Tank activities displayed differing behaviors depending on who was facilitating the experience for them. Children who received Tinker Tank staff facilitation sought and responded to feedback (89%), requested help in solving problems (44%), connected to others' work (33%), expressed realization (44%), and applied their knowledge to their ideas/creations more so than children participants who received facilitation from caregivers.

Learning behaviors observed among *child* participants who experienced facilitation from *Tinker Tank staff*. (n=9)

Learning behaviors observed among *child* participants who experienced facilitation from *caregivers*. (n=28)



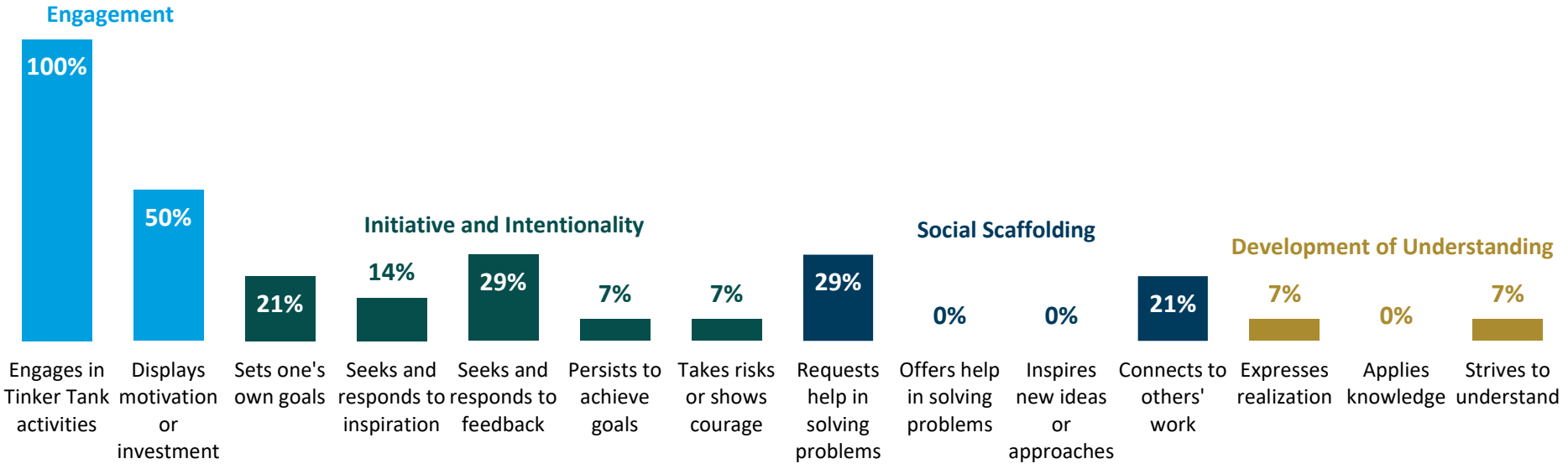
Children participants who received facilitation from other PacSci colleagues displayed learning behaviors that differed from the behaviors observed in participants who received facilitation from Tinker Tank staff. These learning behaviors included setting one's goal (57%), seeking and responding to inspiration (43%), and connecting to others' work (43%).

Learning behaviors observed among *child* participants who experienced facilitation from *SIP staff*, *YFP staff*, and *Tinker Tank volunteers*. (n=14)

The amount of time spent in the activity influenced the types of behaviors observed in Tinker Tank. The longer a participant spent in the Tinker Tank activity, the more learning behaviors PacSci's evaluators were able to observe. Children who spent under five minutes in Tinker Tank all engaged in the activity (100%). More than one-third of the children also displayed motivation or investment in the activity (40%), sought and responded to inspiration (40%) and feedback (40%).

Learning behaviors observed among *child* participants who spent *under five minutes* in Tinker Tank. (n=24)

Learning behaviors observed among *child* participants who spent *between five and fifteen minutes* in Tinker Tank. (n=21)



Learning behaviors observed among *child* participants who spent *over fifteen minutes* in Tinker Tank. (n=24)

These same trends were not consistent among adult participants who spent time engaging with the Tinker Tank activity. Adult participants who spent less than five minutes or over fifteen minutes in Tinker Tank displayed more learning behaviors than adult participants who spent between five and fifteen minutes in the activity. However, guests who spent between five and fifteen minutes in the Tinker Tank activity displayed more learning behaviors in the categories of "Initiative and Intentionality," specifically seeking and responding to inspiration (57%) and seeking and responding to feedback (57%). The frequency of observable learning behaviors decreased for adult participants who spent over fifteen minutes in Tinker Tank. These participants displayed more facilitation behaviors, such as offering help in solving problems (62%) than adult participants who spent time in Tinker Tank for less than fifteen minutes. While it is difficult to determine the factors for these behaviors with the current sample size, it could be that the more time adult participants spent in the space the more likely their role solidified as facilitator rather than participant.

Learning behaviors observed among *adult* participants who spent *under five minutes* in Tinker Tank. (n=14)

Learning behaviors observed among *adult* participants who spent *between five and fifteen minutes* in Tinker Tank. (n=7)

Learning behaviors observed among *adult* participants who spent *over fifteen minutes* in Tinker Tank. (n=13)

Think Alouds

Twelve think alouds were conducted with Tinker Tank guests as a method to understand the thoughts of participants as they are immersed in the activity. These interactions ranged in time, with the shortest interaction being less than seven minutes (00:06:57) and the longest interaction being nearly an hour long (00:50:00). All participants in the think alouds were in multigenerational (M) groups consisting of at least one adult and one child. Ten of the 12 participants were children.

For many participants, verbalizing thoughts while engaging in the activity was unusual. A few participants required consistent prompting by the evaluator, encouraging verbalizations of their thoughts, intentions, and motivations. This can be seen in the table below with the Hootitat activity. This activity saw the least amount of verbalizations (8 verbalizations) as well as the most amount of verbalizations (30 verbalizations).

Time Spent (hh:mm:ss)	Group	Participant	Activity	Initial Way Participants Engaged with Activity	# of total verbalizations	# of obstacles encountered	# of iterations
00:12:25	M	Child	Building Circuits	Seeking and responding to inspiration	9	2	1
00:22:00	M	Child	Hootitat	Gathering materials	8	1	
00:06:57	M	Child	Hootitat	Setting a goal or intention	8		
00:26:00	M	Child	Hootitat	Setting a goal or intention	22	4	1
00:50:00	M	Child	Hootitat	Setting a goal or intention	30	1	
00:14:32	M	Adult	Scribblebots	Setting a goal or intention	12	1	
00:08:32	M	Child	Scribblebots	Seeking and responding to inspiration	12	4	1
00:29:47	M	Child	Frankentoy	Seeking and responding to inspiration	13	3	
00:26:12	M	Child	Frankentoy	Seeking and responding to inspiration	18	5	1
00:16:02	M	Adult	Building Bridges	Facilitating experience for others	19	2	
00:22:02	M	Child	Make Your Own Board Game	Applying knowledge, connecting to past experiences	11		

00:37:26	M	Child	Wind-Powered Vehicles	Setting a goal or intention	16		

The ways Tinker Tank guests participated in the activity varied. Five participants initially engaged with the activity by setting a goal or intention. The second most frequent engagement was seeking and responding to inspiration. This consisted of participants looking to materials, already made creations, or fellow Tinker Tank participants from which to draw inspiration. In total, the participants verbalized five different ways of initial engagement.

Setting a Goal or Intention

"I'm gonna cover up both ends of the tube, and then add a square base, and keep the tub up." –Child, Hootitat
"I just want to make it like a regular house." –Child, Hootitat
"So I was going to put up walls, and then two more." –Child, Hootitat
"I'm going to build one of these, since I know, with these two, I'll be here for a while." –Adult, Scribblebots
"I have an idea for what I want to make already, so I know what I want to get." –Child, Wind-Powered Vehicles

Seeking and Responding to Inspiration

"My friend is doing this one. That's why I want to do it." –Child, Building Circuits
"I thought these seemed cool." –Child, Scribblebots
"This is so cool!" – Child, Frankentoy
"Are people taking these apart? Can I do that?" –Child, Frankentoy

Gathering Materials

"I probably want scissors." –Child, Hootitat

Facilitating Experience for Others

"I'm helping her. She likes coming to Tinker Tank. She likes to make things like this, so we always come here." –Adult, Building Bridges

Applying Knowledge, Connecting to Past Experiences

"I was thinking about chess, since it's the only board game I know." –Child, Make Your Own Board Game

Ten of the 12 participants ran into obstacles. Obstacles varied for guests and was not age nor activity specific. Encountering an obstacle consisted of the following experiences: test failure, struggling with construction, struggling with materials, feeling frustration, or feeling uncertain about the activity.

Test Failure

"Let's add this big weight on top. Oh, that was too much. It came unsnapped in the middle." – Child, Building Bridges

Struggling with Construction

"It's hard to see how to get this part to turn. I thought about connecting it here, but that doesn't turn." –Adult, Scribblebots

Struggling with Materials

"Rats! Is there any tape, Dad? I need tape." – Child, Hootitat

Feeling Frustration

"I'm annoyed. It won't work." –Child, Scribblebots

Uncertainty about the Activity

"I want to attach the head back together. I don't know how to do this. Did someone attach these? How can I do this?" – Child, Frankentoy

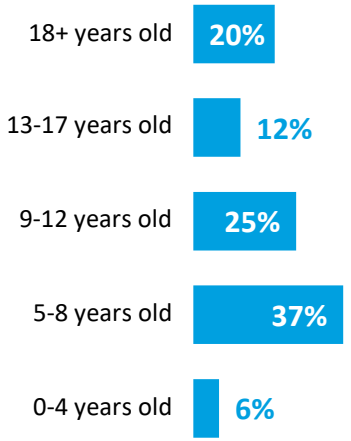
Four of the 12 participants iterated on their Tinker Tank activity creation. Iteration was defined as the process of modifying or adding to a design or creation after conducting a test. Depending on the Tinker Tank activity, testing could include testing for lights to turn on (Building Circuits), robots being able to draw (Sribblebots), and/or declaring a creation completed only to continue modifying and adding to the creation (Hootitat, Frankentoy). For the

Interactive Multiple-Choice Survey

The interactive multiple-choice survey provides a snapshot of Tinker Tank guests. Guests who opt-in to the survey have the opportunity to provide information about their age, motivation for tinkering, who do they make for, where they go to make and tinker, and how tinkering makes them feel.

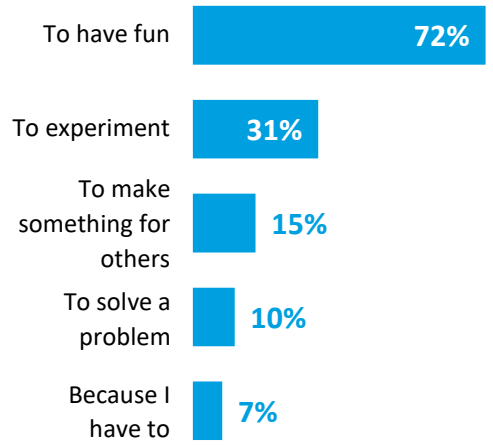
Over one-third of survey respondents (37%) were between the ages of five to eight years old and one-fourth of respondents (25%) were between the ages of nine to twelve years old. Participants who were four years old or younger responded to the survey the least (6%). However, this could be due to the method by which respondents answer the questions. Anecdotally, participants this young did not always have the dexterity to wrap the yarn/string around the peg that denoted the questions' answer. Occasionally, a parent or caregiver would read aloud the question to the young participant and answer the question based on the participants' verbal response.

Over half of the interactive survey respondents are between the ages of five to twelve years old. (n=95)



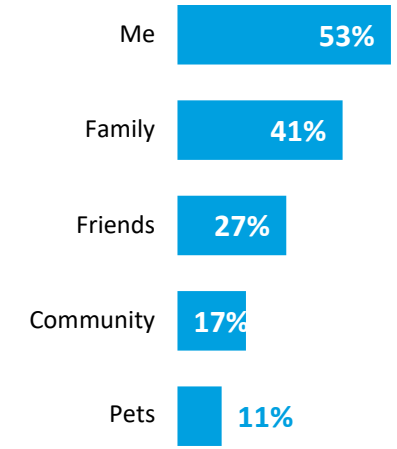
Guests who participated in the interactive multiple-choice survey were asked why they tinker. Five answers were provided on the interactive survey and included the following options: 1) *To make something for others*, 2) *Because I have to*, 3) *To have fun*, 4) *To solve a problem*, and 5) *To experiment*. Guests could select as many answers that best fit their motivation for tinkering, thus the total exceeds 100% on the bar chart to the right. When asked to identify why Tinker Tank guests tinker, nearly three-fourths of survey respondents (72%) said they tinker to have fun. The second most frequent reason why participants tinker is to experiment, with one-third of respondents (31%) selecting this answer. One-fourteenth of guests (7%) tinker because they have to. This was the least selected response.

The majority of respondents tinker *"to have fun"*. (n=97)



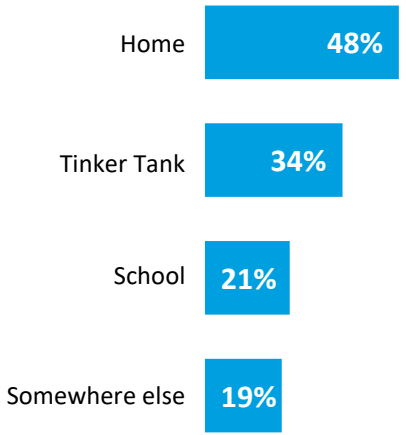
Tinker Tank guests were also asked to identify for whom they make. They could select one or more answers from the five provided responses: 1) *Family*, 2) *Friends*, 3) *Community*, 4) *Me*, and 5) *Pets*. Of the guests who participated in the interactive survey, half (53%) make or tinker for themselves and over one-third of participants (41%) make or tinker for their family members. Additionally, one-fourth (27%) make for their friends, less than one-fifth (17%) make for their community, and one-tenth of survey participants make for their pets.

Participants tinker or make for themselves or their family members. (n=100)



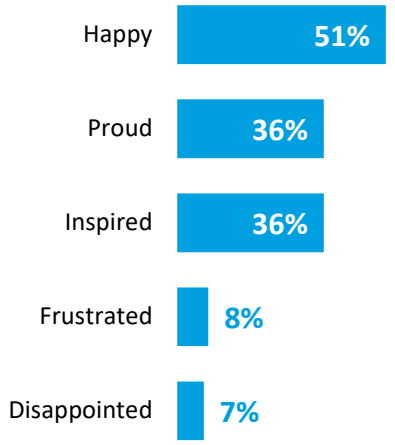
When asked where they go to tinker, nearly half of Tinker Tank guests who participated in the interactive survey (48%) said their home. Similar to the rest of the questions on the interactvie survey, participants had the opportunity to select more than one answer from the four provided options: 1) *Home*, 2) *Tinker Tank*, 3) *School*, and 4) *Somewhere else*. The second most selected answer was Tinker Tank, with one-third of survey participants (34%) saying this is where they go to tinker. One-fifth of participants also mentioned school (21%) and/or somewhere else (19%) as the place where they go to tinker.

One-third of guests go to Tinker Tank to make. This is less than guests who say they make or tinker at home. (n=91)



The last question on the interactive multiple-choice survey asked Tinker Tank guests to identify how tinkering makes them feel. Guests had the opportunity to select one or more of the five options provided: 1) *Inspired*, 2) *Frustrated*, 3) *Proud*, 4) *Disappointed*, and 5) *Happy*. In general, guests selected positive emotions. Half of survey participants (51%) said that tinkering makes them feel happy, one-third (36%) said tinkering makes them feel proud, and an additional one-third (36%) said inspired. Less than one-tenth of guests selected negative emotions and said that tinkering makes them feel frustrated (8%) or disappointed (7%).

Tinkering encourages positive emotions in guests. Half report feeling happy and one-third report feeling proud and/or inspired. (n=92)



Pacific Science Center guests experience Tinker Tank in different ways due to their age and development. Data shows that the majority of Tinker Tank guests range in age, with the majority of guests (62%) being between five to twelve years old. Understanding this data, the following tables will highlight how different age groups experience Tinker Tank.

When looking at why Tinker Tank guests participate in an activity, all children up to four years of age (100%) participate *"to have fun"*. One-third of children up to four years of age (33%) also engage in Tinker Tank activities *"to experiment"*. The majority of Tinker Tank guests, regardless of age, also engaged in the activity *"to have fun"*.

One-third of guests 18 years of age and older (37%) also tinker *"to solve a problem"*. Over one-third of guests between the ages of 13-17 years (40%), one-fourth of guests between the ages of nine to 12 years (26%), and one-third of guests between the ages of five to eight years of age also tinker *"to experiment"*.

Guests tinker for various reasons depending on their age.

	To experiment	To solve a problem	To have fun	Because I have to	To make something for others
18+ years old (n=19)	**26%**	**37%**	**74%**	**11%**	**21%**
13-17 years old (n=10)	**40%**	**10%**	**60%**	**0%**	**30%**
9-12 years (n=23)	**26%**	**0%**	**70%**	**9%**	**9%**
5-8 years old (n=34)	**32%**	**3%**	**71%**	**6%**	**12%**
0-4 years old (n=6)	**33%**	**17%**	**100%**	**0%**	**17%**

When asked whom they make or tinker for, children under the age of four years mentioned friends the most (67%), followed by family (50%) and themselves (50%). Participants between the ages of five to eight years of age make for themselves most often (57%), followed by family (37%). Participants between the ages of nine to 12 years of age followed a similar patter and make for themselves (50%), followed by family (27%) and friends (27%). Teen participants (13-17 years of age) equally make for themselves (70%) as for family members (70%), as do adult participants (18 years of age and older) who make for themselves (47%), family (42%), friends (32%), and the community (32%).

Guests make for various people depending on their age.

	Family	Friends	Community	Me	Pets
18+ years old (n=19)	42%	32%	32%	47%	11%
13-17 years old (n=10)	70%	40%	0%	70%	10%
9-12 years (n=22)	27%	27%	14%	50%	18%
5-8 years old (n=35)	37%	17%	17%	57%	6%
0-4 years old (n=6)	50%	67%	0%	50%	17%

Where Tinker Tank guests go to tinker varies depending on the age of the participant. Two-thirds of guests who four years of age and younger (67%) go to Tinker Tank and one-third (33%) tinker at home. For the rest of the participants, regardless of age, home is where they go to tinker (5-8 years old: 55%; 9-12 years old: 52%; 13-17 years old: 60%; 18+ years old: 56%). Tinker Tank was the second place where participants go to tinker, except for participants who are 18 years of age or older. One-fourth of adult participants (28%) tinker at school and one-fifth (22%) tinker at Tinker Tank.

Guests go home or to Tinker Tank when they want to make.

	Home	School	Tinker Tank	Somewhere else
18+ years old (n=18)	56%	28%	22%	17%
13-17 years old (n=10)	60%	30%	50%	20%
9-12 years (n=21)	52%	14%	33%	19%
5-8 years old (n=31)	55%	26%	45%	26%
0-4 years old (n=3)	33%	0%	67%	0%

As mentioned above, the majority of respondents experienced positive emotions while engaging in Tinker Tank activities. Of the different age ranges, the majority of child participants (5-17 years old) said that *"Tinkering makes [them] feel…happy."* Half of adult participants (18+ years old) said they felt inspired (56%) and proud (50%). Nine to 12 year old participants experienced negative emotions more so than any other age group, with one-fifth of participants saying that tinkering made them feel frustrated (18%) or disappointed (14%). One-third of participants four years of age or younger (33%) also said that tinkering makes them feel disappointed, although this was from a sample size of three.

Guests report feeling positively when tinkering at Tinker Tank.

	Inspired	Frustrated	Proud	Disappointed	Happy
18+ years old (n=18)	56%	11%	50%	0%	39%
13-17 years old (n=11)	45%	0%	36%	9%	64%
9-12 years (n=22)	23%	18%	36%	14%	41%
5-8 years old (n=31)	23%	3%	26%	0%	68%
0-4 years old (n=3)	33%	0%	100%	33%	33%

Conclusions

Visitor Engagement Framework (VEF)

Observations indicate that depending on the activity, guests will experience different Transition and/or Breakthrough behaviors. Rockets saw the highest percentage of Breakthrough behaviors while Tinkering with Bridges saw the least. Additionally, Up in the Air saw the highest percentage of Transition behaviors, while Tinkering with Bridges also saw the least. All learning has value. So it is recommended that the Tinker Tank team explore and select facilitated activities that encourage learning behaviors they wish to foster.

Data also implies that guests who both facilitated and participated in a Tinker Tank activity displayed more Transition and Breakthrough behaviors than guests who exclusively facilitated or exclusively participated. It is recommended that the Tinker Tank team explore and/or develop multigenerational activities for the Tinker Tank space. It is also recommended that further data be collected as sample size is small.

Interviews

Interviews were centered on understanding Tinker Tank guests' experiences with being pushed outside their comfort zone. Occurrences that prompted these feelings included lack of inspiration or running into a roadblock in construction of their project. Methods to overcome these feelings included looking to examples, following a diagram, or changing construction materials. It is recommended that the Tinker Tank team continue to include examples for all facilitated activities. If there is interest in fostering feelings of frustration, consider removing examples and/or diagrams, or adding an additional challenge to the activity.

Nearly all guests said they would do the same facilitated activity again, although depending on age the motivation varied. Enjoying the process of making or tinkering and/or enjoying the nature of the facilitated activity was the primary motivator of repeating the activity for participants under the age of 18. Adults were motived by their children, whether that was for entertainment and/or wanting to encourage children's' learning.

Dimensions of Learning Framework (DoLF)

Similar to the VEF, DoLF measured a variety of learning behaviors by observing certain behaviors. In general, guests more readily engaged in the facilitated activity and displayed motivation for the activity, but were less likely to take risks or inspire others with new ideas. They were also less likely to display behaviors indicative of understanding the approach or outcome of the facilitated activity. Data also indicated that the facilitator influenced which behaviors were exhibited. When Tinker Tank staff facilitated activities, guests displayed more social scaffolding behaviors than when caregivers or volunteers facilitated activities. Further research on Tinker Tank facilitation techniques would be recommend to better understand how to foster specific behaviors and learning dimensions. It is also possible that Tinker Tank staff may self-evaluate and provide modeling or education for other facilitators to engage participants in engaged ways.

Think Alouds

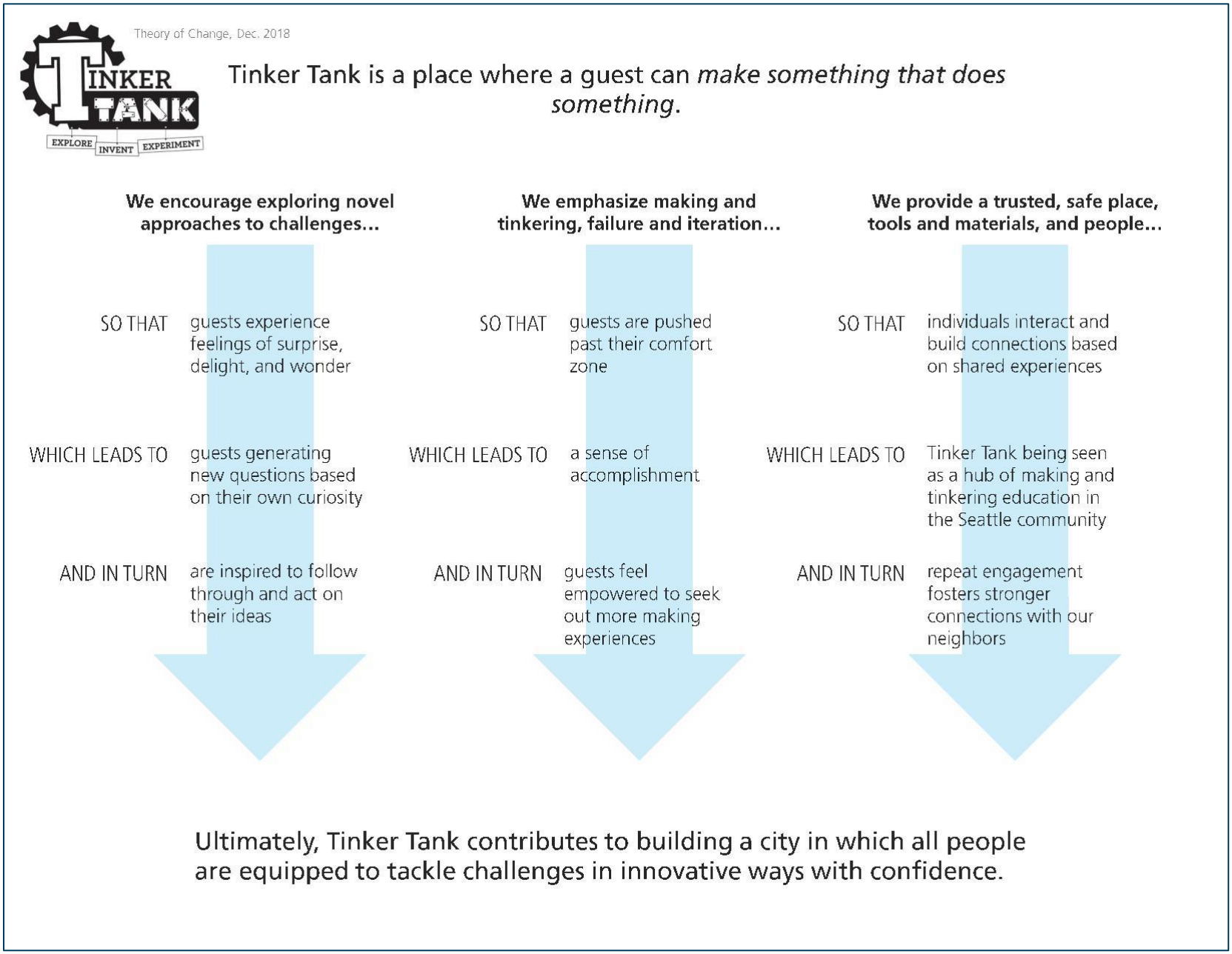
Think alouds provided a unique opportunity to understand the process of making as guests participated in the activity. Small sample sizes provide a more qualitative understanding of the experience, but also limits generalizations of the data. Findings follow the trend of both VEF and DoLF in that guests either set a goal/intention or sought and responded to inspiration as their first engagement. Analysis of transcripts also found that some Tinker Tank participants verbalized thoughts that had little or nothing to do with the facilitated activity. Consider exploring activities that connect to the guests' personal life if there is interest in fostering these connections. Think alouds may also be beneficial periodically when testing new activities.

Interactive Multiple-Choice Survey

During the period of data collection, data from this survey provided insight into the age, motivation for tinkering, for whom they make, where they go to make and tinker, and how tinkering makes them feel. Findings are consistent with data from interviews in that guests make to have fun. They also make for themselves and their families and tinker at home or at Tinker Tank. Guests also experience positive emotions when tinkering. Guests 13 years of age and older were more likely to tinker to experiment, to solve a problem, or to make something for others. Teenagers (13-17 year olds) were more likely to make for themselves and their families. However, for guests five years of age and older, they typically tinker at home. It is recommended to collect data periodically throughout the year or when the Tinker Tank makerspace experiences major changes to continuously gauge guests' experiences. It may be worth exploring how to engage adults in the makerspace by incorporating challenges or contributions to 'real world problems.' This may also encourage making and tinkering at Tinker Tank.

Appendices

Appendix A. Tinker Tank Theory of Change



Appendix B. Evaluation Instruments and Protocols

Instrument 1. Visitor Engagement Framework (VEF)

Date: Activity: Time Spent in Tinker Tank:

Category	Learning Behavior	Observed	Notes
Initiation (orientation to activity)	Support or assistance by staff or other visitor		
	Spending time watching others engaging in the activity		
	Starting the activity		
Transition (once oriented, more purposeful and committed actions)	Expressing positive emotional responses		
	Pushed past comfort zone		
	Completing the activity		
Breakthrough (shows commitment to experience)	Referring to past or future experiences		
	Seeking and sharing information with others		
	Sense of accomplishment		
	Engaged and involved: testing variables, making comparisons		

Subject: Group Members: ☐ Facilitating ☐ Participating

Observations - Visitor Engagement Framework (VEF) Protocol

Background

The Visitor Engagement Framework (VEF) is an evaluation tool that was developed by Chantal Barriault in 1998, in order to assess visitor learning in Science Center settings by identifying observable learning behaviors displayed by visitors, as they interacted with hands-on exhibits. The behaviors Barriault described were grouped into three categories, each subsequent category reflecting an increasing level of engagement and learning: Initiation, Transition, and Breakthrough. Initiation behaviors, as defined by Barriault, consist of doing the activity or spending time watching others engaging in the activity. Transition behaviors follow on from Initiation behaviors, and consist of repeating the activity, and expressing positive emotional responses in response to engaging in the activity. Breakthrough behaviors represent the deepest level of learning and engagement, and consist of referring to past experiences while engaging in the activity, seeking and sharing information with others, and being engaged and involved.

If you would like to learn more about the VEF, and Barriault's research, see: Chantal Barriault & David Pearson (2010): Assessing Exhibits for Learning in Science Centers: A Practical Tool, Visitor Studies, 13:1, 90-106 (http://dx.doi.org/10.1080/10645571003618824).

Development and Adaptation

Barriault's Visitor Engagement Framework has been adapted many times, for many different types of settings and exhibits, beyond just Science Center settings. The adaptability of the Visitor Engagement Framework made it a good choice for modifying for use in Tinker Tank. The behaviors noted above are very broadly defined, so it is possible to redefine the observable indicators of engagement in a more specific sense, within the context of a specific exhibit (Doing the Activity becoming turning on a light by a prism, or listening to an audio recording of a spoken poem and writing a response in a book, or touching a starfish in a tidal pool, etc.).

The VEF is best suited to being used for hands-on exhibits and experiences, making it a good choice for adapting for use in evaluating learning in Tinker Tank. However, in adapting the VEF, we had to take into account the differences between engagement with interactive exhibits, and engagement with a Maker Space. Engagements in Tinker Tank can often be particularly extended and rich, and our own Framework had to account for what that engagement looks like.

In order to develop our instrument, we did initial general observations in Tinker Tank, and then tried to map out the behaviors observed onto Barriault's categories of engagement. Differences became clear quickly. For example, Barriault's "Doing the activity" is described as an Initiation behavior. However, in Tinker Tank, doing the activity, in the sense of completing, testing, and iterating upon, a project, represents a deeper level of extended engagement than something like standing on a scale that shows your weight on different planets. So, we placed "Starting the Activity" into the Initiation category, instead. "Completing the Activity" (that is, a first round of creation and testing of completed project)

became a Transition behavior. We decided "Engaged and Involved: Testing Variables, Making Comparisons" (that is, failure and iteration, testing and modifying a project based upon those test results) represented the Breakthrough level of learning and engagement within Tinker Tank.

We also thought it was important to connect some of these observable learning behaviors to elements of Tinker Tank's Theory of Change, which we used to guide the questions we were asking in our evaluation. Behaviors we called out included visitors being pushed outside their comfort zones (we determined this was observable as expressions of frustration at failures and setbacks), visitors experiencing surprise, delight, and wonder (which we connected to Barriault's Transition behavior, "expressing positive emotional responses in response to engaging in the activity"), or expressing a sense of accomplishment (a Breakthrough behavior).

Please see the charts below for examples of how we related common visitor behaviors from the initial rounds of observation to the VEF framework, during the process of developing the instrument.

Category	**Learning behaviors (**Barriault's and **mine)**	**What it looks like in TT (from ToC)**	**Specific examples**
Initiation (orientation to activity)	Doing the activity	It could be called "starting the activity" instead, expressing wanting to make something, creating something	"Circuits!" sits down at table, "I'll try this rubber duckie one." Choosing what type of circuit to build, "Hmm.. what should I attach it to?" developing project idea
	Spending time watching others engaging in the activity	Also include testing out someone else's creation	Taking picture of someone else doing activity
	Support or assistance by staff or other visitor	Staff greeting, providing materials,	"What's this one?" asks staff

Transition (once oriented, more purposeful and committed actions)	Expressing positive emotional responses in reaction to engaging in the activity	**Guests experience feelings of surprise, delight, and wonder**	"That worked!", laughter when duck motor circuit is tested, "Ha! We did it!"
	Repeating the activity	"Completing the activity", including one round of creation and testing	Testing
	Pushed past comfort zone	Frustration, failure	Testing circuit fails, group struggles to identify problem, tries something else + that works – they form hypothesis about why that worked, "why isn't this working?" expressing frustration, "Nothing's working."
Breakthrough (shows commitment to gaining information and to further explore ideas being presented, relevance to individual's everyday life)	Referring to past or future experiences while engaging in the activity	Also includes: **Guests feel empowered to seek out more making experiences**	"Like a piston in a car?" person compares duck motor function
	Seeking and sharing information with others	**Individuals interact and build connections based on shared experiences**	Group member explaining what components are to other group members, sharing info about how a successful circuit had been built, talking with volunteer about why fan might not be working though LED is
	Engaged and involved: testing variables, making comparisons, using information gained from activity	**Failure and iteration** (Repeating activity several times, multiple rounds of testing), **Generating their own questions based on their own curiosity, Following through and acting on ideas**	"What if we just connect the meter and nothing else?" group tries it "Now, you've got 4 volts instead of 3!", "Can we make two of them?", Trying to figure out why switch didn't work when light did – change configuration to test each block – try different wires, "What do you think? Should we put a switch between the power and the motor?"
	Sense of accomplishment	Showing off, recording/photographing your creation	Showing finished circuit to group member

Initiation Behaviors (Orientation to Activity):

Learning Behavior	Tinker Tank Behaviors	Examples
Support or assistance by staff or other visitor	Staff greeting visitor, providing materials	Listens to staff member explain why he built example bridge using that particular design. Reading TT sign about the day's activity and looking at the examples on the desk. TT staff introduce activity and materials. Picking up a challenge card to select activity. Group member explains premise of activity to visitor. Adult supplies materials to child in group.
Spending time watching others engage in the activity	Includes testing out someone else's creation	Testing the examples that the TT staff provided. Watching another group member build a project. Goes to talk to other groups—"What are you building?" he asks, and watches them work on stuff. "Look at the examples. Which one do you want to try?"
Starting the activity	Expressing wanting to make something, creating something	Begin building something. Gathering components and determining idea: "I wanna build a walking machine!" "I can make a helicopter." Selecting materials and beginning to connect them. Modifying a structure left by a previous group. Building cooperatively with a group member.

Transition Behaviors (Once Oriented, More Purposeful and Committed Actions):

Learning Behavior	Tinker Tank Behaviors	Examples
Expressing positive emotional responses	Guests experience feelings of surprise, delight, and wonder	Choosing to stay in TT and keep building, rather than go to see a film, when asked by his mom which thing he might like to do. "Oh, this is so cool! Look, they're building bridges!" says adult to kid. Laughing and smiling as she points out that the k'nex structure that she is building looks like a magic wand. She bops group member on the shoulder with it, and laughs some more.

		Kid grins and laughs when adult shows what he built to her, asking "Do you like it?" "Yeah!" she responds.
Pushed past comfort zone	Frustration, failure	Crumpling up design sketch in frustration. "This is tough!" Bridge buckles under added weight when tested, and he isn't sure what to do to get it to hold up. "Why am I still doing this?" Asking for help. "How am I going to hold my bridge together? That's what I need to solve." "It's too hard!"
Completing the activity	One round of creation and testing	Builds and then tests completed circuit. Completing and testing, adding increasing weight until bridge fails. "I thinking I'm ready to test my bridge!" Takes bridge to the testing table.

Breakthrough Behaviors:

Learning Behavior	Tinker Tank Behaviors	Examples
Referring to past or future experiences	Includes guests feeling empowered to seek out more making experiences	"I do home snap circuits," referring to past making at home. "I once built a bridge that was really big." "They're building bridges today, not robots" (referring to a past experience with another TT activity.)
Seeking and sharing information with others	Individuals interact and build connections based on shared experiences	Talks to other adult in the group about how the circuit works, speculating on how power moves through each of the circuit components. Asks staff about how they could use a three-way switch to get it to behave like a two-way switch. Demonstrating to parents how to connect the k'nex pieces, so that they lock together more strongly. Getting feedback on design from a group member after testing it.
Sense of accomplishment	Showing off, recording/photographing your creation	"Look what I did!" Kid brings project to show to parent at the other table. "We're making a giant machine!" Showing project off to the TT staff member.

		"It's an engine for a tank. It's going to be the best!" kid asserts.
Engaged and involved: testing variables, making comparisons	Failure and iteration: repeating activity several times, multiple rounds of testing, generating their own questions based on their own curiosity, following through and acting on ideas	Adding/removing a component and repeating the test to see what changes. Changing the project design, after it initially fails. Making comparisons between her own bridge, and an example bridge that she had tested earlier, when prompted by a question from a TT volunteer.

After using the initial version of the instrument, the main changes added to it dealt with the inclusion of contextual information. We added sections of the instrument's margin to enter the activity name, the date, group composition, and whether the participant was an adult or a child. We began numbering behaviors in the order in which they occurred, so that we could reconstruct sequences of events during analysis. We also added a timing component; it was clear that it was important to be able to tell whether few behaviors were noted during a long engagement, or if it was due to the participant only having been in the facilitated activity space for a short time. Similarly, we soon took note of the role adults might have as facilitators. Facilitating adults might show breakthrough behaviors while helping a child with a project, despite never having begun a project of their own. For this reason, we added checkboxes where the data collector could note whether the visitor was facilitating, participating, or both.

Procedures

Materials needed

- copies of the VEF worksheet
- writing tool (pencil is best!)
- clipboard
- a stopwatch or timer

Protocol

1. As visitors approach the facilitated activity, select the fourth visitor to enter the space as the person you will be following.
2. As soon as engagement begins, utilize the stop watch to time the duration of their engagement with the Facilitated activity.
3. On the top of the instrument page note the date and the name of the facilitated activity.
4. On the bottom of the page is a space for the subject you are observing (note A for adult and c for child).
5. Note down the group composition, and whether the visitor is facilitating (assisting and observing group member who is making a project), participating (actively making a project, themselves), or both.
6. Note your initials in the corner of the worksheet.
7. As behaviors occur, write them down as quickly and completely as you can, placing them into the categories they align with. Number them, so that we can see the order in which they occurred.
8. Stop timing when the visitor leaves the Facilitated Activity space of Tinker Tank.
9. After the visitor leaves the space, you will begin a new set of observations for the first new visitor to enter the space and engage with the activity, as before.

Notes

- Since the goal is to observe a visitor from beginning to end of their engagement in the facilitated activity in Tinker Tank, wait for new visitors to approach the activity and engage, rather than selecting visitors who have already begun their engagement when you enter the space to begin collecting data. Do not change who you are observing, once you have begun doing so. Be systematic, so that you can obtain a random sample.
- First, familiarize yourself with the instrument, and the examples of behaviors mapped onto the instrument, so that you can quickly categorize behaviors on the sheet, once you begin collecting data.
- Since a lot of the behaviors (especially the Breakthrough behaviors) are identified in conversational content, being able to overhear what the visitor you are observing is saying is important. Ideally, the best way to both hear conversation and take quick detailed notes, is to sit down at the table the visitor is working at, with your clipboard. If something does prevent you from following conversation (crowds, background noise, language barrier, etc.), just note that on your worksheet's margins. Your goal is to make detailed observations without disrupting the visitors' experience.
- You will see visitors skip back and forth from Initiation to Breakthrough, and back again, or from Transition to Initiation. Behaviors won't necessarily proceed in the order you expect. If it is a lengthy engagement, you will need to write in fairly small print, because there will often be more behaviors than there is space on the worksheet. If you accidentally write a behavior in the wrong place, simply indicate with an arrow the space on the worksheet where it is meant to go (similarly, if you need to use the margins of the worksheet as extra writing space, simply indicate with arrows the categories into which noted behaviors should be placed).
- The ideal way to conduct these observations, particularly initially, is with a partner. That way, you can each observe the same visitor, and then check afterward to see if you categorized behaviors you observed in the same way. This will help clarify behaviors and categories as they are observed on the Science Center floor, and improve reliability.

Date: Activity: Initials:

Tinker Tank Interview

Have you been to Tinker Tank before? ☐ Yes ☐ No

Are you a Member of Pacific Science Center? ☐ Yes ☐ No

Did you work on this project by yourself or with a group? ☐ By myself ☐ Group

Did you get any help from a staff member? ☐ Yes ☐ No

Can you tell me about what you made today? (Prompts: What does it do?)

What problem were you trying to solve?

What were you thinking about while you were working on this?

Were there any points when you felt pushed outside your comfort zone? ☐ Yes ☐ No

(Prompt: Are there any times that you felt frustrated? Challenged?)

If yes: What happened? If no: Why do you think that is?

If yes: What did you do next?

Have you ever done an activity like this before? ☐ Yes ☐ No

Can you tell me more about what activity it was and where you did that?

Would you like to do something like this again in the future? ☐ Yes ☐ No

Why or why not?

If interviewing a child, ask also: How old are you?

For interviewer to fill out:

Who was the primary person you talked to (the one who did the activity)?

Was there a secondary person in the interview (parent or other group member)?

Group composition:

Interviews Protocol

Background

The interview was developed in order to address the gaps in what we learned through observation. In the interview, we are able to ask visitors directly about their experience building a project, rather than looking for behavioral indicators. For example, we struggled with identifying frustration, because we wanted to know the source of that frustration, and how and why visitors were able to move past it (or not). In an interview, we could ask visitors directly about their points of struggle. We drew on what we had learned through the VEF observations to formulate questions, finding and addressing additional gaps in our data as we conducted evaluation, and spoke with Tinker Tank staff about preliminary findings. We tried to keep the Theory of Change as the guide in our instrument design, and returned to it when reconsidering phrasing of questions.

We wanted to get a better sense of the audience in Tinker Tank, so we asked about whether the visitors had been to the space before, and whether they were members. We asked them about whether they had done similar activities in the past. We were also able to ask about their enjoyment of the activity, whether they might wish to do a similar project in the future. These questions allowed us to get a sense of where Tinker Tank fit into the larger spectrum of visitors' learning and making experiences. We were able to ask visitors directly about what they enjoyed about their experiences in Tinker Tank. Interviews allow visitors to express their experience and opinion to us, in their own words.

Development and Adaptation

The interview has gone through several revisions, ultimately having five paper drafts, and we tried many slightly different phrasings of questions and prompts. We found that, because of the nature of the facilitated activity space, where visitors are seated and working on often time-consuming projects, visitors were more willing to complete a lengthy interview than they might have been in other exhibit spaces. Because of this, we were able to add new questions, and follow-up questions, as we discovered lines of inquiry we wished to pursue, rather than leaving those to be addressed in a later instrument.

One of the earliest changes was to differentiate between group composition, and secondary participants in the interview. Both of these were important pieces of contextual information to take note of, but were not the same. Additionally, the follow-up question "Why do you think that is?" to "no" responses to "Were there any points where something you tried didn't work?" was added to the interview protocol, though it was not formally added to the instrument until later. If participants did not struggle with the activity, it seemed important to ask where that sense of ease came from, and not just what they struggled with, and how they moved past it.

The wording of one of the primary questions changed from the initial, "Were there any points when something you tried didn't work?" to "Are there any times when you felt frustrated?" in order to try to pull out more of the emotional struggle of the making experience, and how people responded to failure. Then, in order to more closely align to the element of the Theory of Change for Tinker Tank, we changed the wording a third time, asking, "Were there any points when you were working on your project when you felt pushed outside of your comfort zone?" We had been working from the data from the observations, where frustration was used as an observable indicator for being pushed outside of one's comfort zone, but the interview allowed us to ask about visitors' comfort zone directly. This allowed us

to capture struggle that wasn't encompassed by the emotion of frustration, but rather by the feeling of being outside of one's comfort zone. However, it is a slightly tricky question for younger children to parse the meaning of, and may occasionally need to be rephrased, as a prompt.

We also added to the contextual questions at the beginning of the interview. We asked whether visitors worked on their project alone, or as part of a group, in order to get a better sense of how group dynamics related to the project. We asked whether a staff member had helped the visitor. Both these questions also helped give us an idea of what sort of facilitation, if any, might have been involved during the building process.

After meeting with Tinker Tank staff, we added a question about whether visitors had done a similar project before, and then added a follow-up question, asking what that project was, and where they had done it. This sheds some light into what experiences visitors view as similar to making at Pacific Science Center, and how the Tinker Tank project fits into the larger context of their learning experiences.

The initial prompt, "Can you tell me about what you made today?" sometimes resulted in short, un-nuanced answers, so it gained a prompt, "What does it do?" This encouraged visitors to elaborate on the mechanical and problem-solving elements of their creations. For example, a visitor who answered "I made a boat," might elaborate with, "It carries the duck in the boat to the end of the track, because the sail catches the air from the fan." Two follow-up questions were also tried. The first, "What problem were you trying to solve?" allowed visitors to elaborate on both their goal, and points during the project where they got stuck, or struggled. Interestingly, the same visitors who spoke of trying to find a solution to a difficult problem, wouldn't necessarily respond that they felt pushed outside of their comfort zone, when asked later in the interview. The other follow-up question was, "What were you thinking about while you were working on this?" This produced an interesting variety of responses from visitors. Some focused on the building process itself, some on the formation of their project idea or a source of inspiration, and some on problems and the problem-solving process.

Procedures

Materials needed

- copies of the interview
- writing tool (pencil is best!)
- clipboard

Protocol

1. When a group or individual has completed testing, approach them, and ask whether they (or anyone within the group who worked on the project) would be willing to participate in an interview about what they made at Tinker Tank. Select every third person, or group, to complete and test a project.
2. Before beginning the interview, make sure you note contextual information at the bottom of the paper. Group composition (A for adult and c for child.), the date and activity name, as well as your initials, go on the top of the page.
3. Once the visitor has consented to participate, begin asking the interview questions, and note their responses as completely and quickly as you can.

4. Once you get to the bottom of the sheet, note the participant's information down. Are they an adult, or a child? Note this down. Did someone else participate in the interview, as a secondary participant? If so, make a note of that.
5. Thank the interview participant for their help, and their time!
6. After the interviewee has departed (or you have stepped away, after having thanked them), read through the interview sheet quickly, to make sure you have got the visitor's responses down completely.
7. Repeat the process with the next third visitor to complete their project to the stage of testing it.

Notes

- For the interview, you do not need to follow the visitor from beginning to end of their experience. You do, however, need them to have completed the project to the point that they have tested what they have made. If you can get visitors to participate in the interview as they are on their way out of Tinker Tank, that is most ideal.
- Be systematic in approaching potential interviewees, so that you are getting a random sample of visitors working on projects.
- Be friendly, and make sure the visitor knows that participation is voluntary, and that it is okay to decline. If a child is shy and wants another group member to help with answering the questions, that is fine! Just note that information down on the interview sheet.
- Similarly, if a visitor has to leave before completing the interview, simply make a note at the top of the sheet to indicate that it is incomplete.
- If the visitor doesn't know the answer to a question, simply note that.
- Some questions may need rephrasing, or a further prompt, in order to draw out a response. Some good prompts are: "Why do you think that is?" "Tell me more about that," or "What did you do next?" It's also helpful to repeat a visitor's answer back, and ask for confirmation of whether you have understood their response correctly (this also gives you extra time to finish jotting down longer answers).

Instrument 3. Dimensions of Learning Framework (DoLF)

Learning and Facilitation Framework: Dimensions of Learning at Pacific Science Center's Tinker Tank Data collector initials: _____

Key
Subject: A = Adult C = Child
Facilitator: TT = Tinker Tank SIP = Science Interpretation Programs YFP = Youth & Family Programs SOW = Science on Wheels V = Volunteer(s) CG = Caregiver

Learning Dimension					Engagement		Initiative, Intentionality				
Indicator					Engage in Tinker Tank activities	Displaying motivation or investment	Set one's own goal	Seek and respond to inspiration	Seek and respond to feedback	Persist to achieve goals in the problem space	Taking risks, or showing courage
Date	ID	Activity	Subject	Facilitator							
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	10										
	11										
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	15										
	16										
	17										
	18										
	19										
	20										
	21										
	22										
	23										
	24										
	25										

	Social Scaffolding				Development of Understanding			
	Request help in solving problems	Offer help in solving problems	Inspire new ideas or approaches	Connect to others' work	Express realization through affect, utterances, or explanation	Apply knowledge	Strive to understand	Total Time Spent in Activity (hh:mm:ss)
ID								
1								
2								
3								
4								
5								
6								
7								
8								
9								
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11								
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Observations - Dimensions of Learning Framework (DoLF) Protocol

Background

The Dimensions of Learning Framework (DoLF), created in collaboration between the Exploratorium's Tinkering Studio and the Visitor Research and Evaluation Team, laid the foundation for the organization's tinkering experience. Through observation and deep conversation, the Exploratorium defined "fundamental characteristics of tinkering that are reflective of learning."[1]

The four Dimensions of Learning that resulted include Engagement, Initiative and Intentionality, Social Scaffolding, and Development of Understanding. Specific indicators were identified for each dimension, with descriptive behaviors provided to exemplify the learning taking place.

If you would like more info about the Learning & Facilitation Frameworks, see The Tinkering Studio's Learning and Facilitation Frameworks webpage: https://www.exploratorium.edu/tinkering/our-work/learning-and-facilitation-frameworks.

Development and Adaptation

Since the Learning & Facilitation Frameworks were designed for makerspaces, this afforded PacSci the opportunity to modify the DoLF to meet the needs of their own makerspace. Although the Exploratorium makes it clear the intention of the frameworks provided are "tools for discussion rather than rigorous schemes for coding behavior,"[2] the framework provided a lens to determine if the "characteristics of tinkering that are reflective of learning" also occurred in Tinker Tank.

PacSci's Tinker Tank is set up to provide opportunities for science center guests to engage in both facilitated and non-facilitated activities. Facilitated tinkering activities provides room for guests to "make something that does something,"[3] while also having access to materials, tools, and expertise from PacSci colleagues that is not available in the non-facilitated activities. PacSci colleagues encourage guests to explore ideas, invent objects or mechanisms, experiment and test hypotheses, and innovate by posing open-ended questions that empower and/or challenge the guests approach to making.

This inspired PacSci's Evaluation Department to explore the alignment between the Tinkering Studio's indicators for the Dimensions of Learning and the indicators observed in Tinker Tank. Similarities in behaviors observed (indicators) encouraged the Evaluation Department to continue modifying the framework to develop an observation tool that would help Tinker Tank determine which and how the four Dimensions of Learning

[1] Exploratorium. (2018, August). Dimensions of Learning. In *Learning and Facilitation Frameworks*. Retrieved from https://www.exploratorium.edu/tinkering/our-work/learning-and-facilitation-frameworks
[2] Ibid.
[3] Tinker Tank. (2018). *Theory of Change.* Seattle, WA: Pacific Science Center.

occur in the space. Changes to the framework include a modification of the Engagement learning dimension. This included modifying the indicator for Engagement from "Spending time in Tinkering Activities" to "Engag[ing] in Tinker Tank Activities." "Try[ing] something over and over" was moved from the "Spending time in Tinkering activities" to the indicator "Displaying motivation or investment through affect or behavior."

Additional changes to the framework included the addition of Tinker Tank's Theory of Change (ToC) and aligning the goals identified in the ToC with the learning dimensions, indicators, and description of learner's interactions. Below is the modified framework developed for PacSci's Tinker Tank:

Learning Dimensions (Category)	Indicators (Learning Behavior)	Description of learner's interactions (Tinker Tank Behavior)	Alignment with Tinker Tank's Theory of Change
Engagement	Engage in Tinker Tank activities	• Play, envision, make, explore materials, etc.	1. We encourage exploring novel approaches to challenges…
	Display motivation or investment	• Show emotions such as joy, pride, disappointment, frustration • Remain after they appear "finished," and start something new • Try something over and over	
Initiative and Intentionality	Set one's own goals	• State goals or pose problems • Plan steps for future action • Develop unique strategies, tools, objects or outcomes • State intention to continue working outside Tinker Tank	
	Seek and respond to inspiration	• Actively seek out inspiration from peers/facilitator(s)/materials/environment • Innovate approaches in response to inspiration	
	Seek and respond to feedback	• Actively seek out feedback from peers/facilitator(s)/materials/environment • Anticipate further outcomes • Innovate approaches in response to feedback	2. We emphasize making and tinkering, failure and iteration…
	Persist to achieve goals in the problem space	• Persist toward their goal in the face of setbacks or frustration within the problem space • Persist to optimize strategies or solutions	

	Take risks or showing courage	• Disagree with each other's strategies, solutions, or rationales • Try something while indicating lack of confidence in outcome	
Social Scaffolding	Request help in solving problems	• Request ideas and/or approaches • Request tools or materials in service of an idea	2. We emphasize making and tinkering, failure and iteration… 3. We provide a trusted, safe place, tools and materials, and people…
	Offer help in solving problems	• Offer ideas and/or approaches • Offer tools or materials in service of an idea	
	Inspire new ideas or approaches	• Notice, point out, or talk about others' work • Innovate and remix by using or modifying others' ideas or strategies	
	Connect to others' works	• Leave something of their work behind to share with others • Produce work that interacts with other learners' work	3. We provide a trusted, safe place, tools and materials, and people…
Development of Understanding	Express realization	• Show excitement when expressing a realization • Claim to realize or newly make sense of something • Offer explanations for approach and/or outcome	1. We encourage exploring novel approaches to challenges… 2. We emphasize making and tinkering, failure and iteration…
	Apply knowledge	• Connect to prior knowledge, including STEM concepts • Employ what they have learned during their explorations • Elaborate on current work by engaging in increasingly complicated and sophisticated work	
	Strive to understand	• Refine explanation for approach, outcome, possibly by testing and retesting • Indicate *not* knowing (e.g. through surprise, bewilderment, confusion) and remain in the problem space to explore their confusion and build understanding	2. We emphasize making and tinkering, failure and iteration…

The framework directly influenced the development of a data collection instrument whereby the Evaluation Department could document behaviors observed in the facilitated activity space in Tinker Tank.

Procedures

Materials needed

- Copies of the Dimensions of Learning instrument
- Writing tool
- Clipboard
- Stopwatch or timer

Protocol

1. As visitors approach the facilitated activity, select the fourth visitor who engages with the activity as the subject you will be observing.
2. As soon as engagement begins, utilize the stopwatch to time the duration of their engagement with the facilitated activity.
3. In the columns to the left of the indicators note the date, the activity being facilitated, the subject (e.g. A = Adult, C = Child), and the facilitator (e.g. TT = Tinker Tank).
4. As behaviors occur, write the order of the observed behavior along the indicators provided. If necessary, reference the Dimensions of Learning Framework's description of learner's interactions.
5. Stop timing when the subject leaves the facilitated activity space of Tinker Tank.
6. You will begin a new set of observations for the new fourth visitor who engages with the activity, as before.

Notes

- Since the goal is to observe a subject from beginning to end of their engagement in the facilitated activity in Tinker Tank, wait for new visitors to approach the activity and engage, rather than selecting visitors who have already begun their engagement. Do not change who you are observing once you have begun doing so. Be consistent in your approach to observe the fourth visitor who engages with the facilitated activity. This is done to obtain a random sample, and mitigate implicit bias.
- Familiarize yourself with the instrument and the description of learner's interactions found on the Dimensions of Learning Framework. This will help you identify the behaviors observed once you begin collecting data.
- Certain indicators are identified in conversational context. Therefore, being in close proximity to overhear conversations is important. One of the best way to both hear conversation and document the behaviors observed is to sit at the table where the subject is engaged with the activity. Ultimately, your goal is to make detailed observations without disrupting the subject's experience.
- You may observe indicators across all four dimensions of learning. These indicators will not necessarily proceed in the order expected.
- When first collecting data, it is helpful to have a partner collect data as well to ensure consistency in the indicators/behaviors observed and the ways those indicators/behaviors are interpreted. This will help ensure inter-rater reliability, or the degree of agreement among raters/observers.

Initials: Date: Think Aloud # Activity: Participant:

Verbalization	Action/Step in Process

Notes:

Audio Recording: ☐ Y ☐ N
Group Composition:
Time Spent:

Think-Aloud (Facilitated Activity) Protocol

Sampling

Ask every third visitor to approach the facilitated activity space in Tinker Tank whether they might be willing to participate in a Think Aloud while doing the facilitated activity. The goal is to get a random sample of participants ultimately collecting approximately 30-50 think-alouds. When a think-aloud has been completed, approach the next third visitor, as before.

If the think-aloud participant is a child, it is important that the parent is present to give their consent, also. Make it very clear that no one is obligated to participate!

Materials

Paper Instrument

Writing Tool

Recording Device

Introduction

"Hi, I'm part of the Evaluation team at Pacific Science Center. We're conducting research to help us the visitor experience in Tinker Tank. We're asking visitors to do Think-Alouds, talking aloud about their actions and thought processes, as they build a project. Would you be willing to participate?

Is it okay with you if I record the think-aloud? The record is just intended to help make sure I don't miss any details of what you're saying. If you'd prefer, I can also just take notes by hand."

Warm-Up Exercise

To get ready for doing the think-aloud, you can do a practice exercise. One example could be demonstrating, by thinking aloud about answering the question: "How did you get to the Science Center today?" Then have the participants answer the question with a think aloud.

Think Aloud

Let the participant know that you are about to begin recording, and will introduce what you are doing for the recorder. Remind the participants of how the think-aloud will proceed:

"You can build in whatever way you wish, use any of the different materials, and try different things. Don't forget to talk about what you're thinking, as you do so. You aren't just narrating your actions; I want to hear you think through how you solve any problems, what you're feeling, and any questions that occur to you."

Conduct think-aloud.

Make sure to take notes, along with the recording (if participant consents to recording), so that you can keep track of the physical actions happening, and match them to the verbalizations. Contextual information can also be noted down. If any of the verbalized think-aloud needs clarification, or prompts

you to want to address it with a follow-up question, make sure to note that down, so that you can ask about it in the follow-up questions!

Notes

Thinking aloud is not always a comfortable or familiar process. Prompting during think-alouds is essential. Some examples of potential prompts include: "What are you thinking now?" "What's going through your mind?" "Keep talking, what's going through your head?" "You're doing great. Keep thinking aloud. What are you thinking now?"

Transcription Process

Record the material from your notes on the paper instrument, combining with material from the audio recording.

A potential example for a transcription format of think-aloud data is below:

Verbalization	Action	Step in Process
"Lorem Ipsum Lorem Ipsum"	Cutting Lorem Ipsum shape out of cardboard with scissors.	Making rocket fins

Instrument 5. Interactive Multiple-Choice Survey

Survey - Interactive Multiple-Choice Protocol

Background

Inspired by Pacific Science Center's (PacSci) Tinker Tank, this evaluation instrument took a more interactive approach. During the facilitated Tinker Tank activity Cardboard City, PacSci guests are encouraged to create an element of a city out of provided materials (e.g. cardboard, tape, rubber bands, pipe cleaners, etc.). As part of the facilitated activity, guests informally assessed what others had built in the space, determined gaps in the city's offerings, and added to the collectively built city. Examples of elements built include pet shops, buses, skyscrapers, parks, and NASA facilities. Accompanying the activity was a chart created out of poster paper where participants were encouraged to place stickers indicating what they had decided to build (transportation, recreation, education, residential, factories, etc.).

The collaborative nature of this facilitated activity, and the way guests were encouraged to think about what they were adding to the city and why, inspired the Evaluation team to build an interactive tool that assessed motivation, identity, and community among Tinker Tank participants. The Theory of Change (ToC) contained several aspects not addressed through evaluation up to this point. The particular section of the ToC this method attempted to address reads:

> "We (Tinker Tank) provide a trusted, safe place, tools, and materials, and people… SO THAT individuals interact and build connections based on shared experiences WHICH LEADS TO Tinker Tank being seen as a hub of making and tinkering education in the Seattle community AND IN TURN repeat engagement fosters stronger connections with our neighbors."

Rather than conducting a survey, PacSci's Evaluation team sought to create a data collection instrument in the spirit of Tinker Tank where guests could tangibly contribute. Addressing multiple questions, rather than just one, encouraged broader thinking beyond the creation of a data collection tool that limited responses to a Yes/No or A/B voting system. Additionally, the desired instrument would also take into consideration multiple responses to a single question and would require little facilitation from Tinker Tank and/or Evaluation.

The Evaluation team referred to Tinker Tank staff for ideas and advice, as they were the best source for understanding how to best integrate tinkering with evaluation. Greg Kono, Tinker Tank Specialist, recalled an installation seen at the 2019 Seattle Design Festival. With the assistance of Kono, the Evaluation team developed a tool that Tinker Tank participants could contribute to in a way that resembled working together to make art while also providing data about them and their tinkering identities and motivations.

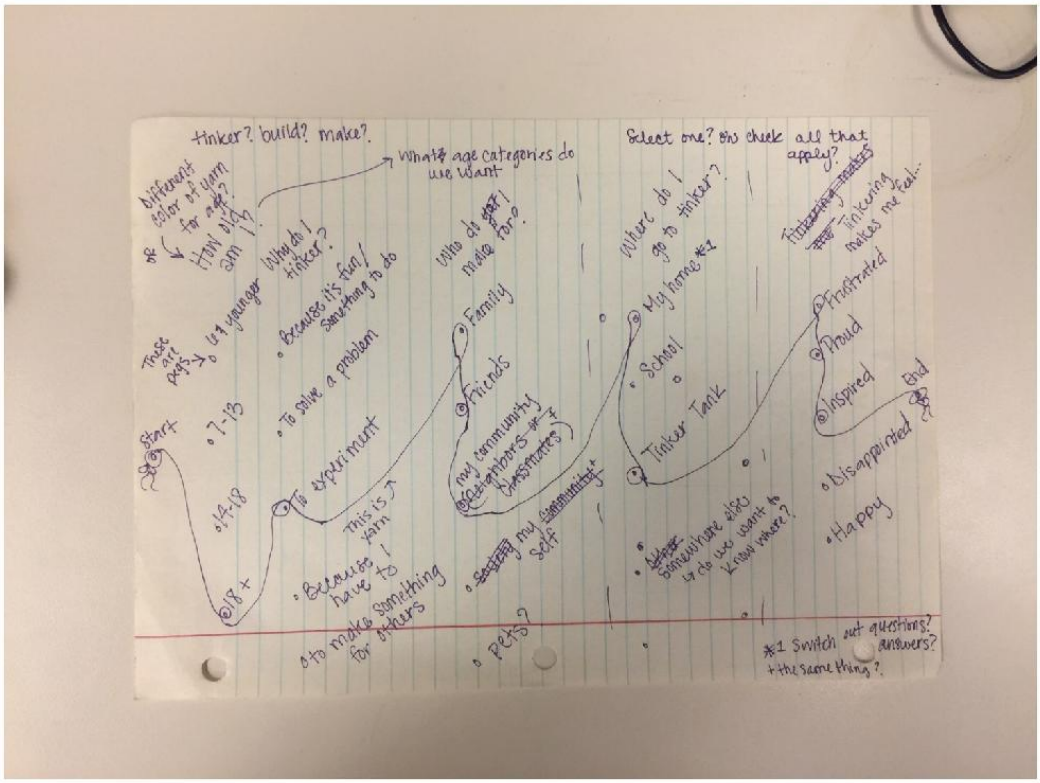
Development and Adaptation

The art installation at the 2019 Seattle Design Festival was a large-scale piece taking up a wall. Size was an important factor to ensure portability within the makerspace and to accommodate different activities and materials. A pegboard, where guests could wrap yarn around pegs to indicate responses to questions (similar to multiple-choice questionnaires with the option to select more than one answer for a question), could provide a strong starting point for the development of the tool.

Anna Lopez, Evaluator, sketched an initial draft of the board, with placement of pegs, preliminary questions and responses, and an example of a Tinker Tank participant's response. Initially, the questions asked of guests were: "How old am I?", "Why do I tinker?", "Who do I make for?", "Where do I go to tinker?", and "Tinkering makes me feel…"

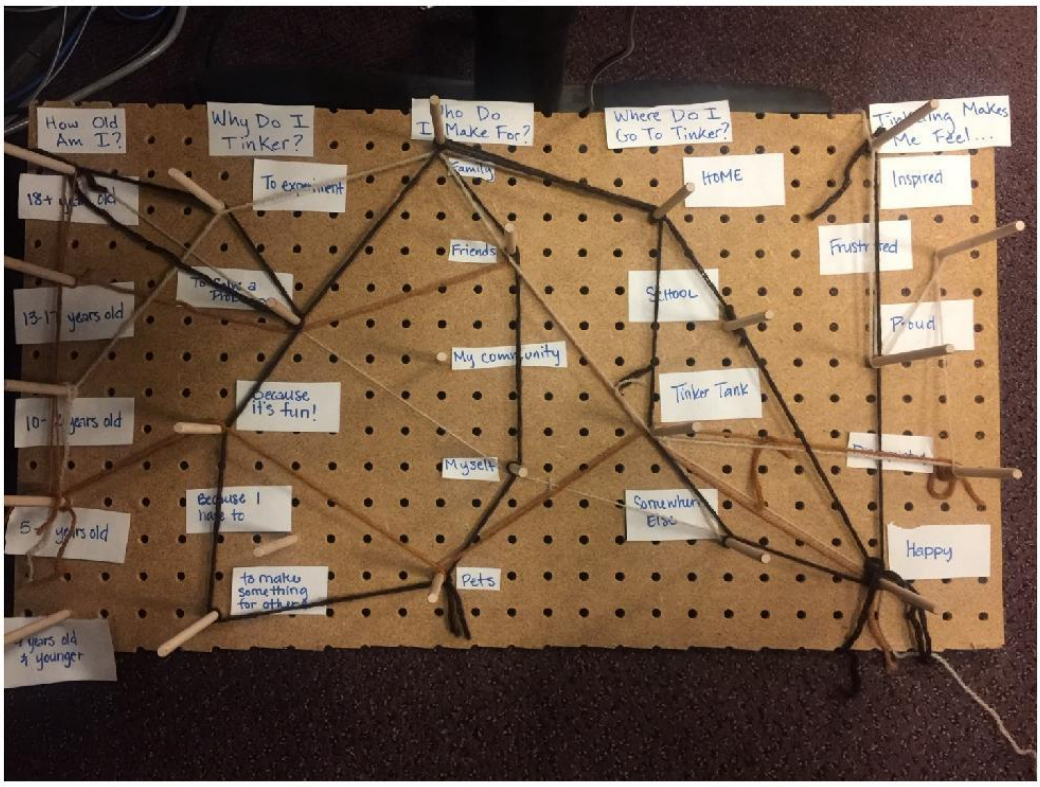
Amount of instruction for the interactive multiple-choice survey was an area of uncertainty for the Evaluation team. Other areas of uncertainty included the denotation of age through the color of yarn and future modifications of the instrument to pose new/different questions and supply new/different responses

Sketch pictured below.



A prototype of the instrument was developed to test and refine in Tinker Tank. A sheet of pegboard, yarn, and pegs supplied by Tinker Tank provided the Evaluation team with the materials to build the prototype. Questions were hand-written paper labels that could be moved and altered during the testing process.

Prototype pictured below.

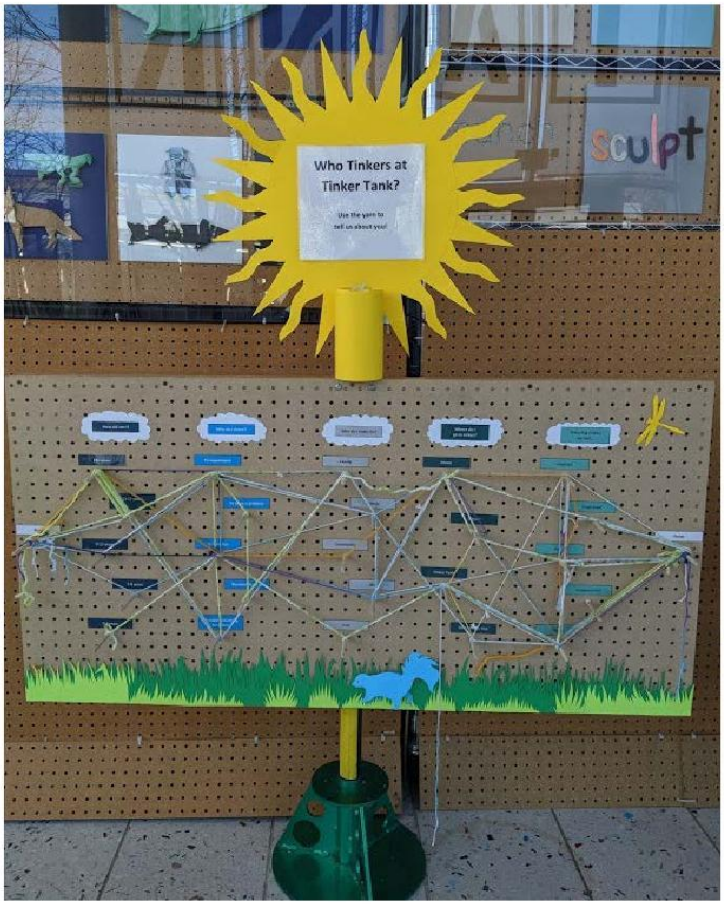


The initial prototype provided learning opportunities for further iteration and refinement of the instrument. Modifications of the instrument included rearranging labels for age responses so younger children could more easily reach the relevant peg. Informal observations found that young children were interested in the tactile element of the interactive and tried to tug on pegs or yarn. They were also interested in trying to answer the questions, but sometimes struggled with wrapping yarn around the pegs. Observations found that caregivers would step in to assist younger children by facilitating and reading the questions or prompting for answers. Caregivers would then answer the questions as well. Observations indicated that guests needed minimal instruction to understand how to use the tool, but encouraged some instruction along the lines of "use the yarn to tell us about you." Modeling a response by having one piece of yarn already set up also provided an invitation to guests to add to the board. Additional modifications included securing the pegs, simplifying the labels and ensuring consistency in the phrasing of the responses, and providing color codes between the question and response.

The final iteration of the interactive multiple-choice survey utilized a larger and heavier piece of the pegboard. Further refinement included securing the pegs with hot-glue, color-coding and laminating labels, staggering pegs, and providing minimal instructions with colorful yarn for Tinker Tank participants to respond. Because Tinker Tank attracts younger audiences (eight years and younger), the final iteration of the interactive survey included a landscape scenery to entice guests in the participation and contribution of data. The scenery exhibits a "sky" (sun, clouds, and flying insects) and "land" (grass, land-based mammals).

Each of the facilitated activities in Tinker Tank lasts a certain duration, approximately one to two weeks. Prior to the start of the new activity, data points from the yarn responses are collected and recorded in an Excel spreadsheet and the survey is reset. This transition affords the Evaluation team to use the activity as a data point for contextual analysis.

The final iteration of the interactive multiple-choice survey pictured below.



Procedures

Materials needed

- A pegboard, or similar, with movable pegs that can be positioned as needed
- Laminated labels for questions, potential answers, and instructional signage
- Yarn
- A container to hold yarn
- Hot glue
- Carpet tape, or other double-sided tape
- Colored paper, or other decorative materials

Protocol

1. Consider what questions you would like to ask your audience. Format the questions and answers so that they are accessible and understandable to multiple age groups, and life experiences. Create and laminate labels.
2. Place pegs into pegboard, so that they are staggered slightly (in order to make multiple answers to a single question stand out more clearly.
3. Place the labels beside their corresponding peg, if applicable, using the double-sided carpet tape.
4. Add an informational sign, inviting visitors to participate in answering the questions.
5. Place yarn for visitors in a container beside, or on, the pegboard.
6. Use a distinct piece of yarn to create an example of how the questions may be answered, for the first visitors who use the board to see.
7. Decorate the board in a manner which invites curiosity and excitement, and evokes the character of the makerspace.
8. When you have determined that you wish to finalize the instrument, glue the pegs in place with hot glue.
9. Collect and record the data left by visitors at regular intervals. If the activity in the makerspace changes, you may wish to collect data corresponding with each activity's time slot.

Notes

- This instrument is opt-in, which limits what data will be collected from it, based on who chooses to interact with the instrument. This instrument requires little facilitation, but, should you wish, it can be utilized with a higher level of evaluator/maker-educator prompting, as well. It can be adjusted to suit the needs of the staff in the makerspace.
- Smaller children struggle with some of the elements of this instrument, so responses from young children (0-4) often involve help and facilitation from accompanying adults.
- It is valuable to prototype this instrument, and get feedback from visitors, and other staff members, on wording and the level of instruction needed.
- It is important to fix the pegs in place, once the instrument has been finalized, and to check on the instrument regularly, because yarn and pegs can otherwise be pulled from the board, causing data loss.

- If you are an evaluator, collaborating with the maker-educators in the makerspace where you are conducting evaluation will be especially valuable, when imagining and creating this instrument for your own space!

Appendix C. Think Aloud Transcripts

Building Circuits

Think Aloud #1 9/22/2019 Participant: Child

Verbalization	Action
"My friend is doing this one. That's why I want to do it."	Sits down at table, picks up block.
"I think I need batteries."	Gets battery pack.
"I don't know what I want to make. What do I connect to it?"	Frowns, looks around table. Uncertain.
"She made a light switch. I want to do that."	Selects materials, double-checking that she has the same material as her friend.
"These clips are hard to use. I need the right color wire."	Attaches alligator clips.
"How come it doesn't work? Mine looks exactly like hers does. I think the batteries are dead."	Completes adding clips and flips switch. Test fails. Looks confused and frustrated.
"I'm going to get my mom to help."	Pulls mom over to help.
The light is broken."	Mom tells her to test light with other batteries. It fails.
"I think I want to try something else, now."	They go to look at what friend is now printing with Turtle Stitch.

Notes: Part of a large group, some are at gravity walls, some at circuits, some at TS, some at wind tunnel—two large families visiting together as a large group, it seems.

Audio Recording: N Time in Activity: 12m25s. Group: Multigenerational

Hootitat--Earthquake

Think Aloud #2 9/28/2019 Participant: Child

Verbalization	Action
"I probably want scissors."	Selecting tools—scissors, paper, straws.
"I chose these because I'm trying to make a house that stands up."	Selecting materials.
"I'm thinking about what an owl will need to survive an earthquake if it happens."	Beginning to combine materials into design.
"I decided to tape the straws because there's no glue."	Taping straws to brochure/map.
"I'm thinking after I add the tape to the straws, I'll put another piece of paper on top. That's the roof."	Goes to get another straw.
"It won't stand up."	Building supports for roof.
"I'm adding the cardboard to hold up the roof."	Struggling to get roof upright, adding cardboard to hold it up.
"I want to bring it home and work on it."	Dad tells her that the group has to leave.

Notes: Left activity before completing it, due to another commitment (laser tickets).

Audio Recording: N Time in Activity: 22m. Group: Multigenerational

Think Aloud #3 9/28/2019 Participant: Child

Verbalization	**Action**
"I'm gonna cover up both ends of the tube, and then add a square base, and keep the tube up."	Forming idea, creates tube, puts owl in it, starts covering one end of paper tube.
"I saw someone else making one like this."	Talks about forming idea, adds another piece of paper to other end of the tube.
"The cardboard is stronger, and will keep it still."	Gets cardboard from bin, starts folding cardboard around tube.
"I'm going to put it on the earthquake thing."	Makes cardboard into triangle-shaped tube around paper tube. Gets into testing line.
"I'm going to do 6.8. I think it's gonna shake around. It might not shake off the table."	Watching other visitor test an owl house on earthquake table.
"That one's really strong."	About earthquake setting.
"7.1? Can I try it? It's not shaking?"	Chooses setting to test. Watches test, and tests again on stronger setting.
"I don't really want to take it home. I'm going to show them."	Goes to show project to family, but decides not to keep it.

Notes:

Audio Recording: Y Time in Activity: 6m57s. Group: Multigenerational

Think Aloud #4 9/28/2019 Participant: Child

Verbalization	Action
"I just want to make it like a regular house."	Verbalizing intention.
"Ooh, sometimes these are good, especially with a magnet… One of these… A stapler!"	Chooses materials and tools (clips, stapler, paper, etc.)
"This is exactly why the stapler comes in handy. Oh, I don't think I need tape…"	Begins folding a piece of cardboard, reflecting on construction method out loud.
"Come on…"	Struggles to get cardboard into desired shape.
"I need a cup!"	Goes back for more materials, can't find a cup, so grabs something else.
"I want to stick the owl in this. Good thing they're squishy! It's like a seatbelt."	Verbalizing ideas for construction, while working.
"Rats!"	Struggling with material.
"Maybe I could just take that out… I'm squishing it in tighter; sometimes that does work."	Tries another idea, modifying what material is being used for what.
"Is there any tape, Dad? I need tape."	Asking group member for help finding tape, while looking around for it.
"Maybe I'm changing it a little."	Referring to original idea changing.
"I'll just use this part, instead. Ta da!"	Changes construction slightly, and then shows project off to group member.
"It's like a boat."	Reflecting aloud on design.
"It needs a seatbelt. I'll use string!"	Adds to design: spots a potential problem, and figures out a solution by adding a seatbelt made of yarn.
"It's coming out better than I thought. Now, I just need this part as a glider. See, I'm pretending it's a glider."	Displays pride in project. Adds novelty—conceives of what he's made as something new.
"It's finished!"	Determines project complete.
"If I turn it like this, this part is a swing."	Adds novelty—conceives of what he's made as something new.
"I think it won't stay."	Joins line to test project. Shows uncertainty about success.
"Okay, which one?"	Watches sibling test a different project, and wonders which setting to test his own project on.
"Bye, bye! …That thing's staying on."	Watches sibling test a different project.
"I'll start here. This part's a glider and a swing."	Shows off project to a volunteer, shows excitement as he begins first test.
"Full power! I want to stand back. I should have built a shield! Uh, oh. …It stayed on, though! The seatbelt worked!"	Watches multiple tests with excitement. Displays pride when project succeeds.
"I want to go do something else now. I'll leave the swing like this."	Loses interest, after completing testing. Interest is caught by other things. Leaves project on table, as an example, in a way that shows off swing.

Notes:

Audio Recording: N Time in Activity: 26m Group: Multigenerational

Think Aloud #5 9/29/2019 Participant: Child

Verbalization	**Action**
"So, I was going to put up walls, and then two more."	Making a start to house, forming idea.
"I'm gonna cut a big piece of tape, but I'm not using all of it for the same thing."	Selecting materials
"I'll make a door, and then a doorknob."	Adding to idea
"I really want to tape the door well, so the owl has a way to get in. I'm going to make a doorbell."	Adding to idea
"Now that I made the door, I'm going to make the rest of the house."	Construction
"I think I needed some more. I need it for designs."	Decorations, adding creative elements to the house.
"This is going to be a circle design."	Decorations, adding creative elements to the house.
"I'm using the twist ties to make designs. I want it to be happy! I'm going to show my Dad the front of the house."	Decorations, adding creative elements to the house. Building on idea.
I'm making something like a tent."	Reflecting on design
"This house needs a lot of tape. Some scraps stuck to it. I should cut that off. I'm going to take mine home."	Reflecting on materials
"I'm making it like a tent, but I need to make it balance."	Struggling
"I think I need to get another paper."	Adding to idea, seeking extra material for it
"It does fit on it."	Material/tool
"I like to use scissors."	Idea, add to design
"I think I know what will make it balance."	Problem-solving
"I'm not making a rocket house! It's not a space house! It has trees inside, because of the green paper."	Reflecting on problem-solving, creativity.
"I'm sure this will work."	Confidence
"I'm going to put some tape."	Devising a solution, getting material
"I'm using this brown piece of paper, because I want to add the other sides."	Adding to house with a new piece of material
"Look!"	Pointing out to group member
"I was sure that would work."	Displaying confidence/pride in solution.
"First, I'm going to cut a bigger piece, so I can cut it into smaller pieces."	Reflecting on use of materials
"It fell under the table."	
"I think I'm finished."	Considers project done, but continues adding to it
"I'm going to build a house, now that I know how. A treehouse. I made a paper house, so I can make a treehouse!"	Displaying confidence. Determines to build a treehouse, for herself, now that she has built a house for the activity.
"I'm adding this to the wall."	
"I think I'm ready to test!"	Decides to test house.
"I think it's going to stay."	Predicts outcome.
"I'm going to pick the smallest one."	Choosing earthquake strength.

"It's going to be a little faster. Go, housey! Go, housey! Go, housey! Daddy, it's withstanding it!"	Excited and proud, jumping up and down.

Notes:

Audio Recording: N Time in Activity: 50 min Group: Multigenerational

Scribblebots

Think Aloud #6 10/26/2019 Participant: Adult

Verbalization	Action
"I'm going to build one of these, since I know, with these two, I'll be here a while."	Decides to make project.
"We have k'nex at home. I try to get them to play with things you have to think a bit about."	Connect activity to past making experiences at home. Getting materials.
"I'm thinking about what I need—motor, wheels, and something like an arm."	Getting materials, thinking about design.
"It's hard to see how to get this part to turn. I thought about connecting it here, but that doesn't turn."	Struggling with construction.
"It reminds me of building a car."	Connect to other idea, knowledge, making experiences.
"I like the motors. I should get some for the kids. We don't have those."	Commenting on materials, talking about future making.
"They're mostly just playing with the ones on the floor that other people made, now!"	Talking about what the kids are doing (playing with example scribblebots on the floor).
"It kind of reminds me of a Spirograph."	Connect to past experience/knowledge.
"I don't think mine's going to be very pretty."	Lack of confidence in what she has built.
"I think I'll use the blue marker. It's here, and it works. I need some clean paper."	Choose materials, getting ready to test.
"That didn't work well, but it draws."	Testing. Mixed feelings about result.
"I could fix it more, but I'd better take them to lunch."	Chooses not to continue project.

Notes:

Audio Recording: N Time in Activity: 00:14:32 Group: Multigenerational

Think Aloud #7 10/27/2019 Participant: Child

Verbalization	**Action**
“I thought this seemed cool.”	Motivation for choosing to do project.
“I don’t really know much about circuits. I want to make an easy one.”	Expresses uncertainty.
“I want to make a light switch.”	Forming idea.
“I’ve got to get wires for it.”	Getting materials.
“These are hard to open.”	Struggling with alligator clips.
“My dad says plus connects to plus.”	Connects to past knowledge.
“I’m going to use this wire, because it’s also red.”	Reasoning for selecting materials.
“It isn’t working. Maybe the battery is dead.”	Test fails. Trying to pinpoint reason.
“I’m going to connect another battery, instead. I’ll use this kind. It looks stronger.”	Modify and retest. Fails again.
“I’m annoyed. It won’t work.”	Expressing frustration.
Asks Dad: “Dad, can you help me?” (Dad points out wires are connected at wrong places, and to switch them.) “Oh, I’m going to do that.”	Asks for help, frustrated.
“It works! I can turn it on and off!”	Tests, and succeeds. Excited and proud.

Notes:

Audio Recording: N Time in Activity: 0:08:23 Group: Multigenerational

Frankentoy

Think Aloud #8 11/3/2019 Participant: Child

Verbalization	Action
"This is so cool!"	Exploring examples/toy parts on table, after activity is explained by staff.
"I want to attach the head back together. I don't know how to do this. Did someone attach these? How can I do this?"	Indicates horse body and cat head. I indicate tape or sewing as options for attaching.
"I've never sewn something. Can you help me?"	She is asking this of me, so I agree, and demonstrate how to thread a needle with one of the plastic needles and some twine. I try to demonstrate a stitch, as well.
"Ummm…"	I struggle with the material and needle, which is too blunt. The knot at the end of the twine then pulls straight through the hole in the fabric—the needle is too big. I then offer to get a metal needle instead. She looks a bit out of her depth.
"I've never used a metal needle before. I'm scared."	I reassure her—"That's okay, I'll show you how to do it safely." She nods, but still looks a bit nervous about it. I demonstrate, and explain how to avoid accidentally catching fingers with the needle. Then I offer it to her, to try. She takes the project.
"Okay. I'm doing it! Look, dad, I'm sewing with a metal needle! I want to show mom! Can we show mom?"	She tries to create stitches, and succeeds, getting more confident and precise as she goes. She is excited and proud, and wants to show work to her parents.
"I'm going to sew the head back up. I need more stuffing, though."	Setting goal. Interested in repair of head, rather than combining toy parts, now. Goes to get more polyfill stuffing.
"I'm adding a bit at a time, as I sew."	Adds polyfill into opening and then continues to sew, and repeats.
"I'm almost at the end! How do I sew this part?"	Question is directed to me. I tie off end of thread after last stitch, and then rethread it, so she can sew the other side of the head. She starts sewing again.
"Mom, look! I'm sewing with a real needle! Can you film me? Look at what I did!"	Mom arrives, and she calls her over to see. She's proud of project.
"Can we stay? I'm almost done."	Wants to finish sewing before leaving TT.
"I want to keep it, but I know I can't."	About project.
I'm going to make toys at home, now."	Set future goal, wanting to extend making experience.

Notes: This is a think aloud where I got pulled into more active facilitation, at the same time as recording—I'm not sure to what extent that shaped things differently than with an outside facilitator, but it certainly may have had an impact. Too much noise in space to record.

Audio Recording: N Time in Activity: 00:29:47 Group: Multigenerational

Think Aloud #9 11/3/2019 Participant: Child

Verbalization	Action
“Are people taking these apart? Can I do that?”	Looking around the table space.
“I don’t want to put them together—I want to use scissors and cut stuff.”	Sets goal. Decides on what he wants to do.
“How do I pick one? Oh, this one. Can I cut off the ear?”	Unsure of how to begin/what materials to choose. Chooses puppy. Double-checking that it is really okay to destroy toy.
“Why won’t it cut? I can’t get it.”	Trying to cut toy. Can’t get through the tough fabric.
“I can’t cut the head off.”	Tries head, instead. Fails. Becoming frustrated, he chooses a different toy—a cowboy pig with thinner fabric.
“I can’t cut the arm!”	Tries to cut arm, fails. Very frustrated. Gets help from his mom. I go to get them adult scissors. She uses them, and helps him get through the first bit of fabric, and then lets him finish.
“Look, its arm came off. I want to take this stuff out.”	Excited that he succeeded. Determines next goal is to pull out all the polyfill stuffing.
“I can’t reach it. The arm is tiny. I’m going to pull it from here, instead.”	Has trouble getting stuffing using initial strategy, tries another opening instead.
“Look! It’s a big piece!”	Holds up a piece of stuffing to show off.
“Now it’s flat.”	Finishes pulling out stuffing.
“Can you cut here? No! Not the pants. Here—this line.”	Wants the boots cut off, asks mom to help him. Objects to where she starts to cut, indicating a seam line, instead.
“Are you done yet?”	Impatient with mom. She finishes, and gives him the toy back.
“I’m taking the stuffing out. It’s a boot, like in Toy Story. They go together.”	Describing what he is doing. Makes comparison to toy boot in film. His mom gives him the other boot, and he starts on that.
“Yours looks gross! I don’t like it.”	Mom shows him her Frankentoy, and he gives negative opinion on it. She asks why he doesn’t like it.
“I just don’t; it’s ugly.”	Reiterates opinion, and his reasoning for why he doesn’t like mom’s project.
“I’m going to tape these back on, again.”	Sets new goal. Tapes unstuffed boots back onto toy where they had been cut from.
“Look! It’s done!”	Shows off finished work to mom.
“I think I’m done now.”	Decides he’s done with project.

Notes: Too loud at table to record.

Audio Recording: N Time in Activity: 00:26:12 Group: Multigenerational

Building Bridges

Think Aloud #10 11/10/2019 Participant: Adult

Verbalization	Action
"I'm helping her. She likes coming to Tinker Tank. She likes to make things like this, so we always come here."	Explains why she comes to Tinker Tank, watching daughter explore materials.
"I think it's good for her to try this out. She has trouble with k'nex, so we work together."	Explains why she thinks this will be a good activity. Her daughter prompts her to work on bridge, so she starts putting materials together. She and daughter build for a bit. (I could not hear all the back and forth here—recording was poor.) I prompt for her thoughts.
"What are we thinking about? (…) Yes, we're thinking about kinds of bridges that we've seen, and what we know about them."	Asking daughter. Daughter says something back (recording is still not clear—but I think it's something about a bridge with a train.) Talks about connecting to things they've seen outside of TT. Applying knowledge of bridges.
"Triangles are the strongest shape, so we're making it based on that."	Applying knowledge.
"These pieces are hard for her to snap together."	Comments on daughter's difficulty with materials. Daughter is getting frustrated, and she helps her.
"It's nice you have the bigger-sized version, but she doesn't like using it."	Indicating Kids K'nex, explaining why they haven't used them.
"Okay, how should we connect this?"	Asking daughter about next part of bridge construction.
"Okay, we're adding these gray pieces to support it, and we're putting the triangles together."	Construction.
"What next? Does it need more?"	Construction. Asking for daughter's input.
"Okay, let's put more pieces to keep the top from flexing."	Construction.
"We're going to test it. She wants to hang the two pound weight from it, so we're putting it between the tables."	Finishes. Decides to test. She explains what daughter said she wanted for test, which is to use the weight with ropes, and suspend the weight from the bridge.
"I think it will hold it."	Predicts outcome. Confident about success.
"It's working!"	Test succeeds.
"Should we add more?"	Asks daughter, who indicates yes.
"Let's add this big weight on top."	Adds more weight on top of bridge.
"Oh, that was too much. It came unsnapped in the middle."	Fails. Locates point of failure.
"Do you want to fix it?"	Asks daughter if she wants to keep working on it.
"Do you want to put a sticker on the poster we looked at? Okay, let's do that."	Asks about adding bridge length/weight marker to chart. Daughter nods, and they move to the poster.
"I think we did pretty good!"	Happy with project.

Notes:

Audio Recording: Y Time in Activity: 16m2s Group: Multigenerational

Make Your Own Board Game

Think Aloud #11 11/28/2019 Participant: Child

Verbalization	Action
I was thinking about chess, since it's the only board game I know.	Gets paper and pencil.
I'm still thinking.	Writes out: Title: Kitten Tycoon Idea: Sorry and Monopoly Rules: Pieces: Kittens
I'm thinking of how in Monopoly and Sorry, you can send pieces back to the start—I'm going to do that with the pawns.	Starts drawing the game board, adds title and a picture of a cat.
I'm making it both (the kitten is the tycoon, you are the tycoon of kittens).	Divides board into quadrants with a number of three cats in each.
It's based on my cat book, the game Sorry, and the game Trouble.	Draws crown on cat. Draws squares.
I'm thinking about making the squares around the board. You have to get your three cats all the way around and back to their home, to win.	
The fish give you speed.	Draws fish in several of the squares.
I think that's it. I don't need more.	Finishes sketching out board.
I'm thinking about my conference tomorrow, and that my school is having a Scholastic Book Fair.	Gets markers to color it. Starts with pink for the cat, then gray for the fish.
The pink for the cat is because it looks more cute, the gray for the fish is to make them look more like real fish.	Yellow for crown, and the "K" in Kitten. Adds rainbow colors.
Can I take this home? Or do I have to leave it here? (I answer that she can take it home if she wants to, so that she can try out playing it.)	Her Dad reminds her that it is time for them to leave, to get to the next thing.

Notes: Forgot to bring the recorder with me

Audio Recording: N Time Spent: 22m2s Group: Multigenerational

Wind-Powered Vehicles

Think Aloud #12 11/30/2019 Participant: Child

Verbalization	Action
I have an idea for what I want to make already, so I know what I want to get.	Selecting materials for project, after looking at the track size and the examples on the table.
The bottom of the boat is cardboard, but I'm wrapping it in the tissue paper to help it slide.	Cutting out a cardboard rectangle for the bottom of the boat. She then starts carefully wrapping tissue paper around the piece of cardboard.
I'm using tape on each side.	Securing each end of tissue with tape with a method a bit like wrapping a present.
Aside to other kid at table: What's your name? (kid answers, and she responds with her own.) What are you making? (Other kid holds up her own project.)	Has a quick conversation with the other girl working at the table, whose father has gone to talk with the volunteer. Other kid is a bit shy, so it's a fairly short conversation.
I don't want it to be too bulky.	Turns back to project, finishing with tape.
It needs a sail, but this is too big. It won't stay up—I don't have a stick.	Looking at the coffee filters.
I'm going to fold a bunch of these into triangles, and use them as the sail. They'll be a lot stronger.	Gets stack of filters, and starts carefully folding them into equally sized triangles, until she has a small stack of them.
This cardboard—I'm cutting it smaller so it holds up the sail like a stick, and I'm going to attach them (the sails) to it.	Cutting a narrow piece of cardboard thinner, to make a mast.
I'm focusing.	
Can I have the stapler?	
It's better for this.	Attaching sails in a stack to the cardboard mast.
Is that a 3D printer?! (I answer that it is, and tell her a little about it.)	Looking behind me, at the 3D printer, which is currently printing. Gets really excited about it. Asks me about it, and I tell her a bit about how it works/is used.
Does that mean I could print out a boat? (I say, probably yes, but she'll need Matt to get it set up.) Okay, I want to do that next!	Anxious to try printer, but still determined to finish her project. Focuses back on finishing up boat. Finishes adjusting mast and adds lego.
I'm going to try it.	Tests.
It went pretty far, but moved kind of slow at the end of the tube.	Comes back to table to tell me about what happened.
Now I wants to try the printer. Can I, please?	Asks me—I grab Matt to get help get her set up to start printing.

Notes: