

Voyage through the Solar System Physical Kit Activities: Formative Evaluation Report

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Executive Summary

Background and overview

Voyage through the Solar System is a collaboration between Sciencenter, Museum of Life and Science, and the Science Museum of Minnesota to develop and distribute a suite of activities focused on human space exploration. This project includes the development of a toolkit of new hands-on facilitated museum activities, and a mobile app with both app-based activities and DIY activities. The toolkit expands on the Explore Science series from the NISE Network and will be distributed to 350 NISE Network partner sites. This evaluation report focuses on the formative evaluation of the facilitated museum activities.

The primary goals of the activities were to engage audiences in STEM learning related to the human exploration of space. There were three facilitated activities

- **Breath of Fresh Air:** A wet chemistry activity using Zeolite to demonstrate how air is filtered and treated so astronauts can breathe in space
- **Build a Moon Base:** A building activity explaining that living and working on the moon requires more than just basic human survival
- **Space Medallion:** A creative activity where participants design their own space medallion and learn about space medallions commemorate space missions and human ingenuity

Methods

Cued observations and a paper follow-up survey were conducted by Evaluation staff across five days in February 2023. Three different activities were facilitated by trained museum gallery staff and interns at an activity bench on level 3 at the Science Museum of Minnesota (SMM). Sampling was continuous and random. Eval staff recruited participants by identifying multi-generational groups on the floor of SMM who had at least one adult and one child in 4th-8th grade (9 - 14 years old) and asking them if they wanted to test out a new activity. Verbal consent and assent was obtained by adults and children.

Table 1. Formative evaluation questions for the facilitated activities

Evaluation Questions	Main data sources
2. To what extent are products engaging for the public?	<ul style="list-style-type: none"> ● Observations ● Survey data ● Facilitator reflections
3. To what extent do the kit activities increase the public’s interest, awareness, and knowledge about space exploration, science, and engineering?	<ul style="list-style-type: none"> ● Observations ● Survey data
4. To what extent do kit activities influence participants’ attitudes about human exploration and NASA missions?	<ul style="list-style-type: none"> ● Observations ● Survey data

Note: Evaluation Question 1 is not included in this report because it was related to the app activities only, not the in-person kit testing on which this report is focused.

Sample

Table 2. Overview of sample size and duration by activity

Activity	# of cases	Avg. Duration
Breath of Fresh Air	10	6 min.
Moon Base	8	16 min.
Space Medallion	9	8 min.
Total	27	

- Average group size: 3.1
- Average time spent on the activities: 10 minutes
- Groups most frequently had 1 adult (17 groups)
- Groups most frequently had 1 child between the ages of 9 - 14 (15 groups). There were 9 groups with two kids ages 9 - 14 and 3 groups with three kids ages 9-14
- In total, 42 children (5 boys: 4 girls) between the ages of 9-14 participated in the activities
- Majority of adults who filled out the demographics identified as white (85%) and women (81%)

Summary of findings

Overall

- Overall, groups enjoyed doing the activities and found them interesting.
- Most groups reported that they learned something new from the activity. “Space Medallion” is the only activity where participants may have struggled to make learning connections during the experience.

- Most adults tended to watch or prompt children off to the side while the children completed the hands-on activities.

Eval. Question #2. To what extent are products engaging for the public?

Breath of Fresh Air

- Overall, participants enjoyed the activity and found it interesting.
- Groups enjoyed the interactivity and watching the chemical reactions; a few groups wondered more about Zeolite after participating.

Build a Moon Base

- Overall, participants found the activity interesting and enjoyable. Groups mentioned that they already enjoy building things or playing with legos, that it was fun, enjoyed the challenges and strategizing, and liked that they could connect it to what they were learning about space in school.
- The average hold time for this activity was noticeably higher than the other activities (16 minutes compared to 6-8) and groups would do multiple challenges.
- Groups also enjoyed using the challenge cards, which prompted strategizing and discussion.

Space Medallion

- Overall, groups enjoyed the activity and found it interesting. Many groups appreciated the creative aspect and that they got to keep a souvenir.
- Participants appreciated the ability to connect what they were doing to their personal lives and reflect on how they'd go to space.

Eval. Question #3. To what extent do the kit activities increase the public's interest, awareness, and knowledge about space exploration, science, and engineering?

Breath of Fresh Air

- Nearly all groups agreed that they learned something new from the activity. Participants shared that they learned about how CO₂ affects astronauts, and about Zeolite.

Build a Moon Base

- While most groups indicated that they learned something new from the activity, a few (2) disagreed.
- When asked what they learned, groups reported learning how things that work on earth may not work on the moon, why it's important to be strategic about what to bring with them, and that things should be arranged intentionally.

Space Medallion

- Nearly all groups shared that they learned something new from the activity, although a few (2) disagreed.
- Groups shared that they did not know what space medallions were prior to participating in the activity.

Eval. Question #4. To what extent do kit activities influence participants' attitudes about human exploration and NASA missions?

Breath of Fresh Air

- Most groups said that the activity made them more curious about space and space exploration (e.g., about space in general, how astronauts survive, how long they can survive, and about how astronauts make their own air in space), although a small number disagreed/were not sure.

Build a Moon Base

- Most groups said the activity made them more curious about what life is like in space and what kinds of things astronauts choose to bring with them, although a small number said it did not make them more curious or that they already did not care about space as a topic generally.
- The challenges seemed to spark more curiosity about space exploration and survival.

Space Medallion

- Most groups said the activity made them more curious about space medallions and/or space in general and it seemed to be a novel topic, although a small number said they were not more curious about space.

Recommendations

Breath of Fresh Air

- Format of activity
 - Highlighters were hard to color with, and larger tip highlighters may simplify the coloring process.
 - Lighting made it difficult to see the color change- maybe test out different colors and make sure lighting is sufficient, or use a light colored background.
- Content of activity
 - The activity would likely benefit from a stronger focus on space and space exploration at the very beginning of the activity from the facilitator.
 - Kids found this interesting and the phenomenon exciting, but didn't always make the connection with the space station or extended missions. Additional prompts, guidance, or descriptives (like images) for facilitators may be helpful.

Build a Moon Base

- Format of activity
 - Visitors often requested more gray blocks for constructions (e.g., to make roofs, taller walls).
 - Facilitators may benefit from more instructions/prompts about guiding children through the “rules” of the initial activity (how many green and blue blocks you need, why you have to choose, etc.).
 - Some visitors used the challenge cards as a ‘matching game’ between the blue/green pieces which may have stifled deeper conversation or discussion around the concept of survive and thrive. Additional guidance for facilitators may also be useful to help visitors explore what each challenge card means. While most groups did try the challenge cards, they often didn't fully understand what made it a ‘challenge’. Clarifying the prompts or reformatting may help.
- Content of activity
 - Adults may not be as hooked into the building activity with their older children because content may not appear as novel, new, or collaborative when older children do not require immediate scaffolding for the activity. Some additional content intended to hook adults could encourage them to maintain engagement in the activity.

Space Medallion

- Format of activity
 - Visitors were interested in additional ways to customize their space medallion - make a keychain, different colors for materials (strings, different color aluminum, etc.) to help it reflect their own individuality and personality.
 - Visitors also required support upfront; an example of a space medallion may be useful for visitors and facilitators.

- Content of activity
 - Medallions are a NASA thing, so may not be a global phenomenon and may need some more exposition.
 - Space Medallion would probably benefit from more intentional exposition materials for facilitators that connects why making a medallion is connected to human space exploration.

Detailed Findings

Eval. Question #2. To what extent are products engaging for the public?

Table 3. 'How enjoyable was the activity?' These are the quantitative results.

	Not enjoyable	Only a little enjoyable	Fairly enjoyable	Very enjoyable
Breath of Fresh Air	-	-	5	5
Moon Base	-	-	3	5
Space Medallion	-	-	4	5
Total	-	-	12	15

Table 4. 'How interesting was the activity?' These are the quantitative results.

	Not interesting	Only a little interesting	Fairly interesting	Very interesting
Breath of Fresh Air	-	-	2	8
Moon Base	-	1	1	6
Space Medallion	-	1	4	4
Total	-	2	7	18

Breath of Fresh Air

- *Successes:*
 - Many groups said that the chemical reaction (color and temperature changes) was cool and facilitators/eval staff noticed that engagement often increased after the chemical reactions.
 - Groups enjoyed that it was an interactive activity where you can “see and not just learn it”.
 - Activity encouraged further investigation into the topic:
 - One group wondered what happens to Zeolite if you blow into it again and tested it out, acting on their own curiosities.
 - Two groups inquired more about Zeolite (“Trees take in carbon dioxide - does that mean that they have the zeolite?”; “How much zeolite does it take to keep the air breathable in space?”).
- *Shortfalls:*
 - Problems with coloring/materials:

Putting the Zeolite in. It turns yellow again. It turns warm and how the water turned. Blowing the bubbles cleared it.
It was cool how it related to space, also that it bubbled.
How the water filtered out the color beads made it come back.
When you were stirring and turned back to yellow.
The color going away.
Color changing. Didn't realize they could ___ when swishing. And blowing oxygen. CM: When we blew balloons and made the color disappear.
Changing colors - and it getting really hot.

Table 5. 'What if anything would you want to change about the activity [Breath of Fresh Air] to make it work better for your group?'

More steps; more hands on.
Nothing.
It worked pretty well.
Change the highlighter color. Put highlighter higher up.
More instructions on how long to blow into it. And how long to do things.
Don't think there's anything.
A little bigger cup would be easier to use the yellow marker.
Nothing.
No.
I would change the highlighter - maybe food coloring? Or use bigger highlighters.

Table 6. 'Is there anything else you want to tell us about this activity [Breath of Fresh Air] and how it worked for your group?'

It was cool. It was interesting. I learned something. It was a lot of fun.
More explanation at the beginning. More instructions. Overall it was good.
It was exciting - something not thought about before.
No. It has good potential.
Very interesting, everybody engaged. If the highlighter was orange it might be easier to see. Not sure if it was easier to see or if it would work - but it was hard to see on the beige table under the light. Oxygen: What the _ of the materials is in space.

Build a Moon Base

- *Successes:*
 - Groups mentioned that they already enjoy building things or playing with legos, that it was fun, enjoyed the challenges and strategizing, and liked that they could connect it to what they were learning about space in school.
 - Many groups mentioned that they found the challenge cards most engaging and often wanted to complete one or more challenges.
 - Children would talk through their strategies when the facilitator would prompt them to, which both seemed to result in them strategizing more often as well as allowed facilitators/observers to see if they were understanding the point.
- *Shortfalls:*
 - Had some difficulty with adults engaging in the activity, especially if more than one child above age 9 - they would sometimes “drop kids off” and go to other things or other group members nearby- could be a recruiting issue more than activity issue.
 - Multiple groups mentioned that they wished there were more building materials (e.g., gray blocks, things to make a roof, more thrive block choices).
- *Group Interactions:*
 - Facilitator would support discussion by prompting kids to talk about their block placement decisions (e.g., “Did you have a reason for putting the water next to the bed?”).
 - Adults often sat next to the children as the children drove the building,
 - occasionally asking questions (e.g., “Oh, is that where you will keep the supplies?”), prompting them to think about certain things, or making suggestions.
 - Some children moved through everything very quickly trying to complete the challenges, whereas others took more time to strategize and talk with facilitators, adults, or other children.
 - Groups with more than one child had variety in how all children participated, often one child (usually an older one) would “drive” the activity, whereas the others would either watch/support, or give verbal suggestions.
- *Open-Ended Survey Responses:*

Table 3b. ‘How enjoyable was the activity? [Build a Moon Base]’

-Older sister is not a huge fan of spaces, likes to look at pictures of space, though. -The younger sister likes learning about space
-I like legos, enjoyed the challenges, related to school lessons, although they were only learning about the solar system and not really moon/space exploration
-Very enjoyable, AF liked watching
Likes doing science/likes science/Want to work at NASA
I guess because I like designing stuff and putting it where I want it. AM: He likes Legos.

Because it's fun making you imagine, but also pretty tough deciding which blocks to use. Tough, but fun.
I like building.
It was fun making stuff. Because you could figure out how to live on the moon.

Table 4b. 'How interesting was the activity? [Build a Moon Base]'

Yes, interesting. Have to think about what people actually do when they are on the moon.
Cool to think about designs, engaging, interactive, strategic.
-Same reason as last question
-placing stuff, strategizing -you can see what you REALLY need- pets are nice but don't NEED them.
Because it's all about strategy - and deciding where the resources would go best. to be able to be healthy.
Because you think of all the stuff you need and consider every option.
I was just interested in it.
Because we could move stuff around. It was challenging.

Table 7. 'What if anything would you want to change about the activity [Build a Moon Base] to make it work better for your group?'

-give more choices for the blue/green blocks -activity a little too easy for age
Said none, they really liked the activity the way it was- maybe more bricks and a lid for the roof.
-CM would have liked more info. about why you needed certain things (the blue/green options) for each challenge (e.g., why is a sleeping bag on the solar storms card)
Not really- would be nice to have more options for the greens. Wish there were blocks for a roof or higher walls (more gray bricks)
CM I think I would change - if one part got damaged, you'd have to move items in that area and recover things. Find a way to repair stuff or find resources. [My interpretation - that could be another challenge card - how to recover or repair in case something happens to your base or part of your base]. AM: Maybe like a little person in the game - and you have different options to choose from.
Probably add more gray blocks.
If it had electric parts.
To work together - talk a little bit more - makes it easier to figure it out. No fighting.

Table 8. Is there anything else you want to tell us about this activity [Build a Moon Base] and how it worked for your group?

No, really really enjoyed it.

AF: As a teacher, she appreciated the directions being written out and on physical cards as opposed to a screen.

Space Medallion

- *Successes:*
 - Multiple groups said that they liked that they were able to draw, make their own design, take it with them and thought it was cool that medallions go to space.
 - One child mentioned that they thought the activity was a good way to learn about people “if you are still making friends” and that it allowed people to show different interests, even if they didn’t like space. Also he liked that it showed the more personal side of space.
 - Being able to connect to personal lives and talking about what they would bring to space seemed to engage both children and adults during the activity.
- *Shortfalls:*
 - Worked better when the facilitator prepped materials (folded tin foil, cut string) and the tracing/drawing worked better than rubbing.
 - Facilitator pointed out that there wasn’t much of a script or more info to share about space medallions.
 - One group were not native English speakers, and there seemed to be some unclarity around the point of the task and the directions.
 - Multiple groups would like more options for customizing (e.g., different colors/materials for the medallion part, could make a keychain).
 - One adult suggested having pictures or examples of space medallions as a model.
- *Group Interactions:*
 - Adults never participated in the drawing, but often sat behind or next to children while they drew, often re-explaining the directions/point of activity, prompting children on what to draw, and making suggestions.
 - Facilitator often asked questions about what is important to them or probed further about personal interests, but generally didn’t need a lot of facilitator support to complete activity.
- *Open-Ended Survey Responses:*

Table 3c. ‘How enjoyable was the activity? [Space Medallion]’

Got to carve what you want, was a fun activity
Shrugged- just liked it.
They both really, really liked the activity and were excited about it. CM said it allowed for a lot of "creative expression" and it was a good way to learn about people if you are still making friends, and that it allowed people to show different interests, even if they didn't like space.
CM: I liked that we got to draw. CF: Same
CM: I've never done anything like this. Very interesting.
CM: I got to draw my own thing, but limited, it's a small drawing space.

CM: Because I got to draw a star and put it on a necklace.
CM2: Neat to know these go to space. CF: Because I got to draw.
CF2: Really cool, draw a picture and trace it and take it with you. CF1: Really cool to take with. CM1: Pretty fun, I liked to design. Pretty cool to make on tin foil.

Table 4c. 'How interesting was the activity? [Space Medallion]'

Didn't know that they brought medallions
Didn't know about the medallions.
Helped CM learn about how astronauts might feel about space, more of the personal side of things.
CM: The space aspect
Tracking off paper on foil.
CM: Retracing it on the foil to make lines.
CM: Learning that this goes into space.
CM2: Because you take it to space, awesome!
CM: The fact that we do it on tin foil.

Table 9. 'What if anything would you want to change about the activity [Space Medallion] to make it work better for your group?'

CF said nothing, but AF said that she thinks it would be nice to have ideas/pictures of actual medallions - would be easier for younger children to have models. AF also mentioned that she is a teacher.
CM said nothing, AF said that she wished it was round to be more accurate to what a medallion is.
You could have more options to customize medallion, like different color tinfoils and rope
CM: No. CF: No suggestions.
CM: I don't know. Yeah, it was pretty good.
CM: No
CM: Not really.
CM1: Maybe have these folded over before so we don't have to do it (referring to edges). CM2: Show how these react in space, see them floating around would be cool.
CF2: Make it a keychain or something like that. CM2: I don't know, I thought it was really cool.

Table 10. 'Is there anything else you want to tell us about this activity [Space Medallion] and how it worked for your group?'

A really great activity.
CM: No. AF: I think we should say what the outcome should be at the beginning. This was fun.

CM: It was fun.
AF: Science is cool. CM2: Science rules!
CF2: Really cool activity

Eval. Question #3. To what extent do the kit activities increase the public's interest, awareness, and knowledge about space exploration, science, and engineering?

Table 11. 'Did you learn something new?' These are the quantitative results.

	No	Not sure	Yes
Breath of Fresh Air	-	2	8
Moon Base	2	-	6
Space Medallion	2	-	7
Total	4	2	21

Breath of Fresh Air

- *Successes:*
 - Learned how breathing out carbon dioxide affects astronauts and about chemical reaction and learned about what Zeolite is and does.
- *Open-Ended Survey Responses:*

Table 11a. 'Did you learn something new?' [Breath of Fresh Air]

How astronauts breathe in space. And I learned about a new material - zeolite.
About Zeolite. how the colors changed. That blowing bubbles made it look like water. That they use this stuff for space.
Zeolite and that astronauts use it.
About the carbon dioxide the astronauts breathe it out. How it affects astronauts.
C: If you add zeolite to water creates bubbles. A: And the oxygen comes back.
That in space there is carbon dioxide and they have to use certain things to get rid of it. Why not plants?
FA: The chemical reaction. CM1: That - I don't really know.
Everything, for the most part - except for the highlighter changing color [knew that would happen]. Learned about zeolite.

Build a Moon Base

- *Successes:*

- Groups reported that they learned about how earth designs can vary on the moon and that if you go to the moon, you have to be thoughtful and strategic about what you need versus what you want, as well as how where things are placed matter.
- One person did not know that you can build things on the moon (i.e., the station).
- **Shortfalls:**
 - Wasn't always clear if they were understanding the point of the activity or if they were just putting blocks on the table- facilitators prompting them to think about it or talk through it helped, however.
 - Sometimes the directions could be unclear for both facilitators and the children or they would not read all the way through challenge cards before beginning to build (e.g., Some children would not adhere to the limits of how many of each "survive" and "thrive" blocks they could have- this might be a result of them not really understanding the point of picking and choosing).
- **Open-Ended Survey Responses:**

Table 11b. 'Did you learn something new?' [Build a Moon Base]

-Older rated no (2) and said not really. -Younger rated yes (1) and said that she didn't know you couldn't have enough things to survive on the moon and that you would have to make those choices
-How earth designs vary on other planets, have to be thoughtful. He said he was thinking about Earth when designing the moon base, but knows that the environment would be different on the moon, such as needing to place a cell tower higher up since the signal would be worse on the moon than on Earth.
-Learned that things could happen on the moon base that you would have to think through
You should think about what you really need.
Might have taught me that if I wanted to live on the moon, it teaches us where to put things next to each other and where not to.
AF: Learned to pick and Choose between what you want and need. CF: Yes.
That you could have a signal in outer space. That you can grow plants in outer space.

Space Medallion

- **Successes:**
 - Groups reported that they did not know about space medallions prior to the activity and learned that they could draw on tinfoil (mentioned doing the activity again at home).
 - Facilitators sometimes would have to add more information while the child was drawing if they realized they might not understand what a space medallion was or the point of the activity.
- **Shortfalls:**

- There were some instances where it wasn't clear if some children understood the point of the activity (e.g., drew impersonal pictures such as space ships, did not really answer if they learned anything new when asked).
- *Open-Ended Survey Responses:*

Table 11c. 'Did you learn something new?' [Space Medallion]

Same answer as before, didn't know they brought medallions
That they brought medallions to space.
That people brought medallions to space and that you are able to draw on tinfoil (something he could do at home)
CM: I learned what a space medallion is.
CM: Just about the space medallion.
CM2: I learned that you can take this to space and it won't float off. CF: that you can mark it with your own symbol.
CM: if you draw something on paper and trace it, it will go on foil. CF2: That astronauts take medallions to space.

Eval. Question #4. To what extent do kit activities influence participants' attitudes about human exploration and NASA missions?

Breath of Fresh Air

- *Successes:*
 - Most groups said that BOFA made them more curious about space and space exploration (e.g., about space in general, how astronauts survive, how long they can survive, and about how astronauts make their own air in space).
- *Shortfalls:*
 - A couple of groups said "no", "I don't know" or that they didn't really like space already. Unclear why, but some groups did not already have connection to space or didn't seem to have their attitude changed.
- *Open-Ended Survey Responses:*

Table 12. 'After doing this activity, what are you thinking about space exploration and astronauts?' [Breath of Fresh Air]

That it is pretty cool but I always liked space.
I want to go to space. (AM and AF note: Have to be a billionaire like Besos or Musk to do that.)
Yeah. More interested in space.
They have to use this technique to make it clear. They have to be smart. What is in their thing can run out.
It is really cool how they do that. And that you can recreate it to see instead of just learning.
Curious how long they can go. How many of those beads equals how many hours.

A: More introduction to space.
A: Do you want to be an astronaut? C: No.
AF: More curiosity - finds topic interesting. We have a membership, so come a lot. If we could have more experiments, it could be interesting. Any hands on. CM2: I don't really know.
CM2: That they could survive in space longer. They could have a continuous supply for missions like going to Mars. CM1: didn't know astronauts make their own air. More curious about how. Says he's seen video of them [astronauts] without their suits on at the space station.

Build a Moon Base

- *Successes:*
 - Majority of groups said MB made them more curious about what life is like in space and what kinds of things astronauts choose to bring with them.
 - The challenges seemed to spark more curiosity about what people would actually do if faced with those challenges in real life.
- *Shortfalls:*
 - A few said that it did not make them any more curious about space or that they either didn't care much about space already.
- *Open-Ended Survey Responses:*

Table 13. 'After doing this activity, what are you thinking about space exploration and astronauts?' [Build a Moon Base]

Same/more curious
CM said more curious, was curious what people would actually do in space if faced with these challenges. AF said it was really exciting and she enjoyed watching how interested and engaged CM was.
CM: More curious. Learning about space is fun and very common in their family because their dad is astronomer and runs a star lab.
Both said more curious- like that you can see what you would actually need and not need in space
Think it might be fun. I think I would like to explore space. I like challenges and learning things. Made him more curious - how life could be if really had to live in space. Think it would be hard. Kind of different but could survive.
No, not really. Don't really think about space. Sort of more curious - liked the large astronaut [in other part of the museum].
You can build something on the moon. A station on the moon.
When they are out of water, what do they have to do? [astronauts]. How do they stay alive? Food and water will not always be there. It's challenging to figure things out.

Space Medallion

- *Successes:*
 - Most groups said that SM made them more curious about space medallions and/or space in general.
 - Some reported they did not know about space medallions before the activity, and also did not notice anyone say that they knew about them during the observations- likely a new topic for most.
- *Shortfalls:*
 - A couple said they were not more curious about space and/or were more curious about other things (i.e., ocean).
- *Open-Ended Survey Responses:*

Table 14. ‘After doing this activity, what are you thinking about space exploration and astronauts?’ [Space Medallion]

Is more curious, especially about the medallions. Wants to learn more about that and see examples of medallions
More curious to learn about the medallions.
A little more curious to hear what they store the medallion in and what other personal things astronauts bring to space with them
CM: I'm more curious, I'm not sure. CF: I don't know.
CM: I feel like stuff on Earth is more interesting. Space has already been explored. The bottom of the ocean hasn't been explored as much as space.
CM: Exciting. Nothing new from this.
CM: Interested, because I like learning what they do in space.
CM1: Pretty cool. CM2: I'd love to go to space, been on my bucket list forever. Meet some astronauts, it would be awesome.
CF1: I love astronauts because space and exploring planets. CM: I think being an astronaut would be really cool.