

Facilitating Family Engagement in STEM: Using Video Reflection to Develop Educator Practice

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Biographical Notes

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Abstract

This study examines family-educator interactions during failure moments at one museum exhibit. Family dynamics are complex and can be difficult for museum educators to navigate¹. Failure is part of the engineering design process² and a tool for generative learning experiences in making environments³ but can also be difficult to facilitate. In this study, educators used video reflection to identify, develop, and practice methods to engage multi-generational groups working together during a STEM activity. This paper presents five strategies that educators developed to collaboratively engage children and their adults in iterative design-based activities.

Keywords: reflective practice, museum education, families, video reflection, failure

Introduction

Science museums aim to engage with the public around science content and personalize experiences for all guests, yet family groups tend to prioritize the child experience. Family groups have complex dynamics at play prior to entering the museum and it can be difficult for floor staff to enter those dynamics during free-form exploration⁴. Research has explored many aspects of facilitating learning opportunities in museums⁵, some specifically focusing on families⁶ and facilitating family engagement⁷ and some exploring youth experiences with failure in making⁸, but none has examined facilitating family groups engaging in failure-rich activities.

Failure rich activities are intentionally structured to surface moments of trial and error, inviting participants to experience “failure” as part of the creative process and reflect on how to navigate setbacks. We frame “failure” as part of the engineering design process⁹ and a tool for generative learning experiences in making environments¹⁰. Failure in making could happen for multiple reasons, for example if the object created failed to meet an expectation or if the maker

lacked knowledge. Prior research has shown that informal educators sometimes respond to youth failure by stepping in to resolve the issue¹¹ rather than by helping the youth work through it themselves. Similarly, when a child in a family group is experiencing a moment of failure during a maker activity an adult might take over to “fix it,” thus removing an opportunity for the child to struggle and grow through failure and complicating facilitation for education floor staff. In this study, we expanded from examining individual failure within a family group to include group dynamics. We prioritize the collective engagement of all learners within a family group, and thus define disengagement or not working collaboratively as failure, or not meeting our intended goal as an educational team.

Our research question for this work was: What specific strategies are useful for engaging adults and children working together during a STEM-related activity? One way educators can expand their pedagogical strategies is by reflecting on their own teaching practices using video recorded moments from their facilitation with learners¹². Video reflection offers educators the opportunity to develop their ability to notice, interpret, and respond to moments of failure in ways that support problem solving¹³. We used video reflection during a NSF-funded research project, Failure in Making, and decided to continue to use similar techniques for this investigation.

Background

We designed a professional development that included training around facilitating multigenerational groups through moments of failure in making activities, brainstorming and practicing strategies to try on the museum floor, and creating a community of practice through group reflection sessions¹⁴. The professional development occurred in three parts: (1) discussion around failure in making, (2) discussion around engaging with intergenerational groups,

specifically (a) understanding family context, (b) supporting intergenerational communication, and (c) negotiating family and facilitation goals and (3) video recording and self-reflection.

First author, Elizabeth, adapted prior training materials to inform these sessions, specifically materials developed during our prior Failure in Making work¹⁵ and materials developed during prior research with families at this museum¹⁶. Session participants were five science educators who lead in-museum classroom programs and engage guests in labs and on the floor activities about 35-40 hours each week. Educators had no more than three years of experience at the museum and had prior experience in other informal science settings. The first two professional development discussions took place over a series of seven sessions each 90-120 minutes. During these sessions the museum education team brainstormed a list of strategies to try to use when facilitating failure moments with families. This initial list inspired the goals educators chose to focus on for the first recording session. Video recording and self-reflection occurred in an iterative cycle across five weeks. The list of strategies and goals were continually developed throughout the recording cycle.

For this study, we focused on an activity with specific constraints we thought would lead to failure and iteration. In this activity, guests were given the design problem of creating a hover craft for a pig that could stay within a specific range of a wind tube (see Figure 1).

Figure 1

Wind tube materials (top left) and exhibit (right and bottom left)



Each week, educators would identify a goal for themselves and then work in pairs for two hours on the floor, recording each educator interacting with guests for an hour. Each educator then took about two hours to review their video and pick a 2-5 minute clip to share with the group. Following all individual reflection, the group of five educators would meet to share clips and discuss their strategies, usually around 90-120 minutes each week. During these reflective group video sessions, each educator shared their 2-5 minute video clip. While watching the video, others took notes on the evidence they noticed in relation to the educator's goal, as well as their reflection of the evidence. These notes informed the discussion that followed viewing of each video clip.

Analysis Approach

The video recorded reflection sessions as well as self-observation and group observation forms were collected and analyzed to address our research question around specific strategies used on the museum floor. This analysis began with the self- and group observation forms across the five weeks. Author Amber coded each statement or phrase that referenced a strategy for engaging adults (and children) to work together. For example, the following note was coded as ‘Engage in dialogue that opens up a space for shared participation’ because the educator asked them to talk about their ideas to shift their frustration to collaboration.

Figure 2

Educator notes from a reflection session on 7-30-2024

Record any notes that provide more context for what is happening in the clip:

Adult + child working for a while, this is most frustrating part where they argue + fail, adult had been putting herself down, child was quiet at 1st

EVIDENCE	REACTION & REFLECTION
- What evidence do you see of the learner experiencing failure? How do any adults in their group respond? What do they say or do? - What evidence do you see of the educator facilitating around failure?	- Does the facilitation strategy work? Why or why not? - What does the evidence make you feel, react, think, or wonder?
-adult yells "I don't know, don't ask me" + child yells too - "If you talk about your idea..." educator tries to get them to open up - "One thing you haven't tried - what?" - tells them not to get frustrated, get excited - asks question to get them to see problem - kid making monster noises + adult seemed ready to go	- impressed that educator could get into conversation when they were so frustrated - adult + child talking more calmly at end - they end interaction w/ a plan - wonder how it went + how they were building before together

Once all observation forms were coded, the results were sent to Elizabeth to confirm or disconfirm the patterns. As stated by Elizabeth, "I read through this list a couple of times and I didn't see any

patterns emerge that you didn't already note," therefore, confirming the strategies observed by Amber.

Results

Educators were encouraged to try new strategies when interacting with family members during data collection (e.g., let a group become excited about the activity then introduce design constraints). Analysis of observation and reflection forms highlighted five strategies educators repeatedly tried and reflected upon throughout the reflection sessions. There were additional strategies noted but were excluded from this analysis if the strategy was mentioned in less than three of the five reflection sessions. Strategies were used to inform educator weekly goals and continually updated and developed within their interactions with family groups on the floor. Table 1 showcases the five strategies that were salient to the educators during their reflective video-based sessions.

Table 1

Strategies to engage adults and children to work together

Strategy	Examples
Engage in dialogue that opens up a space for shared participation	Asking adult and kid each what their idea for the team is. Sharing air space for ideas. Giving both space to share & contribute ideas (7-9-24 session). Asked children to work more closely with parent - brainstorm about possible solutions. She was able to redirect the group to work together again with just a simple request. Sometimes all it takes is to remind groups that they should be working together (7-23-24 session)
Extend invitation to engage non-engaged family member, whether child or adult	Adult disengaged - educator invites to join (7-9-24 session) Family wasn't working as a team, some members got left out. Educator asked questions that included the left out members; asked what they thought. The adult was only focused on the bigger kids and did a project with them (7-16-24 session).

Use “team” language to reinforce the idea of working together and collaborating	I tried to address both adults and children - it helped I think. I wanted to combat the perception that it is a kid only activity using "team" language (7-2-24 session). Using language like: "talk to your team"; "what does everyone think", "work together" (7-16-24 session)
Assign roles or jobs for each team member	There was a refocus of roles for each one to play in the interaction (7-9-24 session). The educator asked less interested teammate if they wanted to have a special "job." Got the learner to participate in the challenge (7-30-24 session).
Interact with group, then give space for them to work and later return to check in (i.e., yo-yo)	It seems that the educator was great at giving them space, so she could be less involved in the interaction with the group (7-23-24 session). Circling back by asking to share what he [child] wanted with his grown-up [adult] (7-23-24 session).

While there were instances in which these strategies were effective in terms of family engagement around the activity, there were also instances of the strategies not working as intended. Consider the following examples from two different reflection sessions of one educator, Natalie, attempting to support collaboration through providing a space for family members to be on the same page regarding the design of the prototype.

The younger child is participating less than the adult. The adult took over for a moment.

The educator comes in and involves the younger child by asking questions about materials and her opinion. The strategy worked, the child seemed to have a space to share her ideas and put them in practice. (Evidence & Reflection from Mia on 7-9-24)

To adult, "so you have a vision...a parachute." To kid, "what do you think about a parachute?" Trying to encourage collaboration. Doesn't seem to work for including kid.

Adult continues to be more hands on in the building. (Evidence & Reflection from Edna on 7-23-24)

In these two examples the “failure” was unequal participation or lack of collaboration in the activity, and the educator was attempting to encourage the child to be a more active participant. Both times Natalie used the strategy “extend invitation to engage non-engaged family member” but while this strategy is successful in the first example, it does not work in the second example. Educators often reflected on how they had to understand family dynamics to be more in tune with visitor goals and to figure out which strategy would be received well. For example, Debbie noted,

It’s not one solution for everything. There are all these layers in this. So in here, let’s use this [example], there’s this disengaged mom from the beginning, so how do you just start with that? And then also she has a lot of kids, so maybe by that time also it was too late, it’s tiredness, so how do you grab all these different elements, and help it- (.) cause it’s going to have to hit different- do you set a challenge for every one of them? (Video reflection 7-16-24)

Case of Assigning Roles

In what follows, we showcase Ariel’s strategies over several weeks as she worked to engage adult family members who were disengaged (or failing to engage) in the activity. We highlight one specific strategy - assign roles or jobs - because while it is commonly used to support children’s group work in schools¹⁷, we see this as a new approach to promoting collaboration between adult and child family members in a museum setting. In addition, this case highlights the value of reflecting on instructional approaches as a community of educators.

As noted above, each educator set a goal for an instructional practice to try during the upcoming week. Ariel’s goal the second week - “try using roles to get all members to engage” (self-reflection observation) - was inspired by a discussion following a video clip of one of her colleagues. As stated in the video,

I want to try, inspired by Natalie's idea of what you had tried towards the end of your video and what we were talking about. I kinda wanna try either splitting roles at the beginning or letting them do their (plan for enacting?) and see how that goes. So try handing out more specific roles or jobs at the beginning to each person on the team to see if that helps. (Video reflection 7-16-24)

During the third week, each educator found evidence of Ariel achieving her goal through watching her video clip and documenting this evidence on the group observation forms. For example, Mia noted the following:

The adult took over and did all the building without involving the child. The educator named a role for the child as a tester. It seems like the kid enjoyed that role, but none of the information that the kid gathered was used for the design. (Evidence & Reflection on 7-23-24)

As another example, as observed by Natalie, "The educator assigned team roles to encourage teamwork but it did not work because one teammate was more interested in exploring materials" (Evidence & Reflection on 7-23-24). In these two quotes from Ariel's colleagues, Ariel achieved her goal of assigning a role for the child to be engaged in the challenge as the tester; yet this approach may not have worked as expected. As Ariel stated in her self-reflection, "Tried roles, seemed to make mom feel okay building, but not sure if/how it affected child." At the end of this reflective session, Ariel's goal for the upcoming week was to be more organic and responsive to visitors' goals.

Yet, in the fourth week, Ariel again assigned a child a role - pig caretaker. As observed by Mia,

The family wasn't working together, the adult was working by herself & child was playing by himself. Educator suggest[ed] trying or testing different materials so that they both have a task & they get to work together in the building. The adult seemed to be responsive on the educators suggestion & interactions, as well as the child. Also this interaction didn't feel forced & everybody seems to be enjoying. (Evidence on 7-30-24)

In being organic in her approach to visitors, Ariel utilized a strategy from the prior week to successfully get the family working together. This evidence was also observed by Natalie and reflected upon following the viewing of Ariel's video clip.

I like the strategies you used. I thought they were both effective ways to get somebody engaged. You gave the kid a job to get them involved. And you brought them from here to here...with like that job. "You want to try to put the pig in here?" And that was immediately like come do this, be a part of the experience. (Video reflection on 7-30-24)

While Ariel's goal modified across the weeks, it was always about engaging each member of a family who was failing to work together to get them to collaborate. This case study highlights the usefulness of having specific strategies to use while also being reactive to family dynamics and shifting strategies when one doesn't work as intended.

Discussion

This article showcased the educator perspective in facilitating multigenerational engagement, a perspective we believe is lacking in current literature. Our museum education team brainstormed a list of strategies to use when facilitating family groups experiencing failure moments and educators repeatedly used five of these strategies while on the floor. These strategies, fully described in table 1, include: (a) engage in dialogue that opens up a space for shared participation, (b) extend invitation to non-engaged member, (c) use team language, (d) assign roles, and (e) yo-

yo between interacting with and giving space to the group. These strategies have been noted by researchers in other contexts. For example, the first three strategies focus on using language to invite and encourage shared participation which has been documented as a beneficial strategy for use in museums with children¹⁸, families¹⁹, and with museum educators collaborating 1-1 with guests during failure moments²⁰. Our yo-yo strategy is similar to “wait time”, a common strategy in school for pausing to allow cognitive processing time²¹, though wait time does not usually include the educator stepping away from the activity or conversation. Assigning roles has also been used in school settings with groups of children²². Our work extends and connects this prior research by showing they are all useful for engaging multigenerational groups in iterative design-based activities. These strategies add to and connect the facilitation moves for engaging families in museums²³ with facilitation moves for children in makerspaces²⁴ and facilitation moves for failure in making²⁵. They begin to build a collection of strategies museum educators can use when supporting families through failure moments.

One limitation of this study was that failure moments reflected upon were interpreted by our museum education staff and might not have been seen as failure in the eyes of our guests. However, we contend that the strategies we shared here are useful for shifting the behavior of children and their adults from not collaborating to engaging collaboratively in iterative design-based activities. They are strategies we encourage other museum educators to utilize and build upon in supporting family’s engagement and participation through failure moments.

This work involved a professional development process using video reflection to identify, develop, and practice methods to engage multi-generational groups working together during a STEM activity. Specifically, watching recorded segments of facilitation together allowed our

educators to reflect on their own practice, their colleagues' practice, and grow and build their pedagogical strategies according to their own goals in collaboration with colleagues.

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Notes

1. Pattison & Dierking, "Staff-mediated learning in museums"; Pattison et al., "A design-based research study"
2. Petroski, "To engineer is human"; Simpson & Maltese, "Failure is a major component of learning anything"
3. Maltese, Simpson, & Anderson, "Failing to learn"
4. Pattison & Dierking, "Staff-mediated learning in museums"; Pattison et al., "A design-based research study"
5. Falk, Dierking, & Foutz, "In principle, in practice"; Hein, "Learning in the Museum"; Leinhardt, Crowley, & Knutson, "Learning conversations in museums"
6. Dierking & Falk, "Family behavior and learning"; Ellenbogen, Luke, & Dierking, "Family learning in museums"
7. Pattison et al., "A design-based research study"; Pattison & Dierking, "Exploring staff facilitation that supports family learning"
8. Simpson, Anderson, & Maltese, "Caught on camera"; Simpson, Anderson, Maltese, & Goeke, "I'm Going to Fail"

9. Petroski, "To engineer is human"; Simpson & Maltese, "Failure is a major component of learning anything"
10. Maltese, Simpson, & Anderson, "Failing to learn"
11. Simpson, Anderson, & Maltese, "Caught on camera"
12. Sherin & van Es, "Using video to support teachers"
13. Simpson, Anderson, & Maltese, "ups, downs, and potentials"
14. Dierking & Fox, "Changing the way I teach"; Nolan & Molla, "Teacher confidence and professional capital"
15. Binghamton University, "Failure in Making"
16. Pattison et al., "A design-based research study"; TERC, "REVEAL Professional Development Program"
17. Cohen & Lotan, "Designing groupwork"
18. White, Akiva, Wardrip, & Brahms, "Facilitated making"
19. Pattison & Dierking, "Exploring staff facilitation that supports family learning"
20. Simpson et al., "Co-Construction of Iteration Through Failure Moments"
21. Tobin, "The role of wait time"
22. Cohen & Lotan, "Designing groupwork"
23. Pattison & Dierking, "Exploring staff facilitation that supports family learning"; Gutwill & Allen, "Facilitating family group inquiry"; Pattison et al., "The impact of facilitation"
24. White, Akiva, Wardrip, & Brahms, "Facilitated making"; Kollmann Kunz et al., "Understanding facilitation techniques"; Clapp, Ross, Ryan, & Tishman, "Maker centered learning"; Gutwill, Hido, & Sindorf, "Research to practice"

25. Martin, "The promise of the Maker Movement"; Simpson, Anderson, & Maltese. "Caught on camera"; Vossoughi, Escudé, Kong, & Hooper. "Tinkering, learning & equity"
26. Dierking & Fox, "Changing the way I teach"; Nolan & Molla, "Teacher confidence and professional capital"

Bibliography

- Binghamton University. "Failure in Making" Accessed May 3, 2024, <https://sites.google.com/binghamton.edu/failureinmaking>
- Clapp, Edward P., Jessica Ross, Jennifer O. Ryan, and Shari Tishman. *Maker-centered learning: Empowering young people to shape their worlds*. John Wiley & Sons, 2016.
- Cohen, Elisabeth G., and Rachel A. Lotan. *Designing groupwork: strategies for the heterogeneous classroom third edition*. Teachers College Press, 2014.
- Dierking, Lynn D., and John H. Falk. "Family behavior and learning in informal science settings: A review of the research." *Science Education* 78, no. 1 (1994): 57-72.
- Dierking, Rebecca C., and Roy F. Fox. "'Changing the way I teach' building teacher knowledge, confidence, and autonomy." *Journal of Teacher Education* 64, no. 2 (2013): 129-144.
- Ellenbogen, Kirsten M., Jessica J. Luke, and Lynn D. Dierking. "Family learning in museums: Perspectives on a decade of research." In *In principle, in practice: Museums as learning institutions*, edited by John Howard Falk, Lynn Diane Dierking, and Susan Foutz, 17-30. Rowman Altamira, 2007.
- Falk, John Howard, Lynn Diane Dierking, and Susan Foutz, eds. *In principle, in practice: Museums as learning institutions*. Rowman Altamira, 2007.
- Gutwill, Joshua P., and Sue Allen. "Facilitating family group inquiry at science museum exhibits." *Science Education* 94, no. 4 (2010): 710-742.

- Gutwill, Joshua P., Nina Hido, and Lisa Sindorf. "Research to practice: Observing learning in tinkering activities." *Curator: The Museum Journal* 58, no. 2 (2015): 151-168.
- Hein, George E. *Learning in the Museum*. Routledge, 2002.
- Kollmann Kunz, Elizabeth, Allison Anderson, Marta Beyer, Hever Velázquez, Marjorie Bequette, Gretchen Haupt, and Owen Weitzman. "Understanding Facilitation Techniques for Hands-On Chemistry Activities." *Journal of Museum Education* 48, no. 2 (2023): 122-135.
- Leinhardt, Gaea, Kevin Crowley, and Karen Knutson, eds. *Learning conversations in museums*. Taylor & Francis, 2003.
- Maltese, Adam V., Amber Simpson, and Alice Anderson. "Failing to learn: The impact of failures during making activities." *Thinking Skills and Creativity* 30 (2018): 116-124.
- Martin, Lee. "The promise of the maker movement for education." *Journal of Pre-College Engineering Education Research (J-PEER)* 5, no. 1 (2015): 4.
- Nolan, Andrea, and Tebeje Molla. "Teacher confidence and professional capital." *Teaching and teacher education* 62 (2017): 10-18.
- Pattison, Scott A., and Lynn D. Dierking. "Exploring staff facilitation that supports family learning." *Journal of Museum Education* 37, no. 3 (2012): 69-80.
- Pattison, Scott A., and Lynn D. Dierking. "Staff-mediated learning in museums: A social interaction perspective." *Visitor Studies* 16, no. 2 (2013): 117-143.
- Pattison, Scott A., Scott M. Randol, Marcie Benne, Andee Rubin, Ivel Gontan, Elizabeth Andanen, Crosby Bromley, Smirla Ramos-Montañez, and Lynn D. Dierking. "A design-based research study of staff-facilitated family learning at interactive math exhibits." *Visitor Studies* 20, no. 2 (2017): 138-164.

- Pattison, Scott A., Andee Rubin, Marcie Benne, Ivel Gontan, Elizabeth Andanen, Todd Shagott, Melanie Francisco, Smirla Ramos-Montañez, Crosby Bromley, and Lynn D. Dierking. "The impact of facilitation by museum educators on family learning at interactive math exhibits: a quasi-experimental study." *Visitor Studies* 21, no. 1 (2018): 4-30.
- Petroski, Henry. *To engineer is human: The role of failure in successful design*. St. Martin's Press, 1985.
- Sherin, Miriam, and Elizabeth van Es. "Using video to support teachers' ability to notice classroom interactions." *Journal of technology and teacher education* 13, no. 3 (2005): 475-491.
- Simpson, Amber, and Adam Maltese. "'Failure is a major component of learning anything': The role of failure in the development of STEM professionals." *Journal of Science Education and Technology* 26 (2017): 223-237.
- Simpson, Amber, Alice Anderson, and Adam V. Maltese. "Caught on camera: Youth and educators' noticing of and responding to failure within making contexts." *Journal of Science Education and Technology* 28 (2019): 480-492.
- Simpson, Amber, Alice Anderson, and Adam V. Maltese. "The ups, downs, and potentials of implementing video clubs in museums." *Journal of Museum Education* 48, no. 3 (2023): 306-314.
- Simpson, Amber, Alice Anderson, Adam Maltese, and Megan Goeke. "'I'm Going to Fail': How Youth Interpret Failure Across Contextual Boundaries." *International Society of the Learning Sciences*, 2018.
- Simpson, Amber, Andrew Osterhout, Alice Anderson, Adam V. Maltese, and Jacey Ruisi. "Co-Construction of Iteration Through Failure Moments: Interactions Between Museum Educators and Visitors." *Visitor Studies* 27, no. 2 (2024): 184-206.

TERC. "REVEAL Professional Development Program" Accessed May 3, 2024.

<https://www.terc.edu/reveal/professional-development/>

Tobin, Kenneth. "The role of wait time in higher cognitive level learning." *Review of educational research* 57, no. 1 (1987): 69-95.

Vossoughi, Shirin, Meg Escudé, Fan Kong, and Paula Hooper. "Tinkering, learning & equity in the after-school setting." *In annual FabLearn conference. Palo Alto, CA: Stanford University*. 2013.

White, Annie M., Thomas Akiva, Peter S. Wardrip, and Lisa Brahms. "Facilitated making in museum-based educational makerspaces." *Curator: The Museum Journal* 64, no. 1 (2021): 131-154.