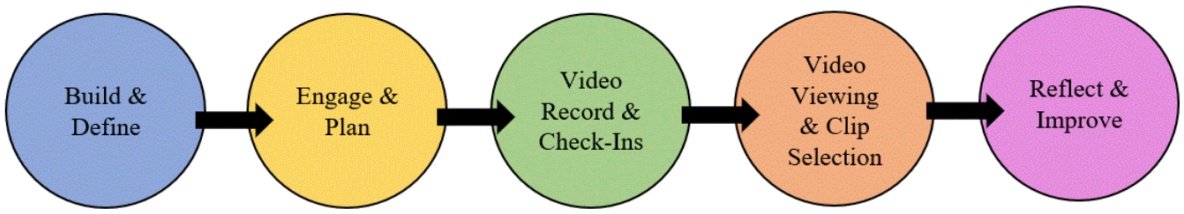
NSF AISL: Collaborative Research
The Notion of Failure and Maker Programming for Youth: Supporting the Professional Development, Reflection, and Learning of Informal Educators



Final Summative Evaluation Report

Prepared for

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EXECUTIVE SUMMARY

This report presents the final summative evaluation of Failure in Making[1] (FiM), a four-year initiative funded by the National Science Foundation through its Advancing Informal STEM Learning (AISL) program. The project was a collaboration among Binghamton University, Indiana University, and the Minneapolis Institute of Art. FiM aimed to support informal educators in fostering resilience and productive responses to failure in youth STEM maker activities through a research-based professional development (PD) model and an open-access online toolkit.

Project Overview and Research Goals

FiM sought to address a persistent challenge in maker-centered learning environments: how to shift educator practices from preventing failure to intentionally designing for productive failure as a catalyst for learning. The project engaged 27 museums nationwide across three cohorts, involving 51 lead facilitators and approximately 160 informal educators. Failure in this context was defined as a situation in which the outcome of the maker experience does not align with the learner's intentions or goals to the task.

The objective of the research was to adapt, implement, and refine a PD program focused on supporting informal educators' instructional practices on ways to plan for and respond to youths' experiences with failure. The aim was to have a positive impact on developing participants' pedagogical practices around failure, as well as developing youths' affinity for resilience during making[2] tasks and a strong sense of self as a maker. To achieve this, the project aimed to:

- Translate research on productive failure and resilience into practical strategies for informal learning contexts.
- Enhance educators' pedagogical practices and confidence in facilitating youth experiences with failure.
- Foster youth resilience, agency, and growth-oriented mindsets in STEAM maker programs.
- Develop and refine a modular, adaptable PD model suitable for diverse institutional contexts.
- Create an online, scalable toolkit to support broader dissemination and sustainability.

Development and Implementation of the PD Model

The FiM team designed, tested, and refined a flexible PD model grounded in the Problem-Solving Cycle by Borko et al. (2015). The PD model was co-developed with museum partners and iteratively improved over four years. Implementation occurred in three phases:

1. Cohort 1 (Co-Development Phase): Six museum partners collaboratively designed and piloted the PD model, providing formative feedback and shaping core features.

[1] The project is referred to as *Failure in Making (FiM)* in this report as this is the name the group used.

[2] Making and tinkering draw on Jean Piaget's constructivist view that learners actively build knowledge through experience and Seymour Papert's constructionism, which emphasizes learning through creating tangible objects and engaging in iterative problem solving, or "hard fun" (Papert, 1980; 2002).

2. Cohort 2 (Expansion and Refinement): The refined model was implemented across 13 additional organizations, demonstrating scalability and stronger implementation outcomes.
3. Cohort 3 (DIY Group): Tested the independent implementation through the open-access online toolkit.

Adult Focus Study: In addition to the cohort-based implementation, the project included a focused exploratory study examining how FiM approaches might support facilitation with adults and caregivers.

The PD emphasized collaborative learning and inquiry, research translation, and reflective practice. Participating sites adapted workshop modules to align with their contexts, audiences, and resources.

Key Features of the PD Program

Evaluation findings identified several core features that supported meaningful pedagogical change:

- Translation of research on productive failure into actionable facilitation strategies.
- Modular design enables contextual adaptation.
- Professional learning communities promoting shared reflection and peer feedback.
- Active learning strategies, including hands-on maker experiences and video analysis or practice.
- Embedded reflective structures to support continuous improvement.
- A learner-centered facilitation approach emphasizing resilience and adaptive responses to failure.

These features supported sustainable shifts in educator mindset and practice.

Impact on Leaders and Educators

The evaluation found significant impact on leadership capacity, instructional practices, and educator mindsets:

- Cohort 1 leaders reported substantial professional growth and increased confidence in training informal educators at their sites to support youth through failure experiences.
- Cohort 2 leaders demonstrated clearer implementation goals, stronger outcomes, and fewer challenges.
- Cohort 3 participants successfully implemented the toolkit independently, reporting positive feedback and practical application.
- Many participating institutions integrated FiM into onboarding, staff training, and cross-departmental initiatives, reflecting institutional commitment.

Leaders and educators reported increased empathy, intentionality, and self-efficacy in supporting youth during moments of struggle. Overall, participants described reframing failure as a productive and necessary component of learning rather than an outcome to avoid.

Youth and Institutional Outcomes

While youth-level data collection presented challenges, qualitative and observational findings indicate meaningful impact:

- Youth demonstrated increased learner agency, independence, and confidence in maker activities.
- Programs increasingly emphasized process over product, encouraging experimentation and iteration and intentionally designed more supportive environments for risk-taking and reflection.
- Youth developed stronger resilience and a more robust sense of identity as makers.

At the institutional level, FiM contributed to:

- Embedding failure and resilience concepts into program design and staff development.
- Strengthening cross-team collaboration and reflective practice.
- Building sustained academic–practice partnerships and national networks.
- Supporting workforce development in informal STEM education.

The open-access FiM toolkit was widely valued for its flexibility and potential to support ongoing and scalable implementation.

Challenges and Limitations

The FiM project navigated several challenges, including pandemic-related disruptions, staff turnover, resource constraints, limitations in youth data collection, and the iterative development of the online toolkit. Virtual engagement posed constraints for some sites, and adaptation across diverse institutional contexts required ongoing refinement.

Overall Effectiveness and Future Directions

Overall, FiM proved to be an effective, adaptable, and scalable professional development model for fostering productive failure in informal STEM learning environments. The project strengthened leaders' in supporting informal educators to create learner-centered, resilience-focused maker experiences and contributed to meaningful institutional change.

FiM demonstrates that a research-informed, collaboratively developed, and modular PD model can produce sustainable pedagogical change across diverse informal STEM learning settings. Continued refinement, dissemination, and expansion of the toolkit will further extend its national impact.

1. INTRODUCTION

The *Failure in Making* (FiM) project was a collaboration between Binghamton University, Indiana University, and the Minneapolis Institute of Art (MIA). Funded by the National Science Foundation's Advancing Informal STEM Learning (NSF AISL) program, the project aimed to adapt, implement, and refine a professional development (PD) program designed to help informal educators recognize, interpret, and respond to youths' experiences with failure in making-based activities. These efforts focused on STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning environments in museums and other informal education settings.

This collaborative research initiative engaged practitioners from 27 museums across three cohorts over four years. Participants included 51 lead facilitators, and approximately 160 informal educators. In Years 1 and 2, six museums (Cohort 1) co-developed, implemented, and tested a PD model to support informal educators in recognizing and productively addressing failure moments during STEAM making activities. In Year 3, the model was refined and expanded with 13 additional museums (Cohort 2), allowing for a broader examination of its implementation, impact, and scalability across diverse institutional contexts. In Year 4, the model was further examined through a Cohort 3 (DIY Group) that engaged additional sites with lighter touch support, intentionally testing the accessibility, adaptability, and effectiveness of the FiM toolkit and associated resources. The FiM project focused on failure due to its critical role in fostering persistence, motivation, self-efficacy, and agency, all essential qualities for success in fields that emphasize innovation and creativity. In this context, failure is defined simply as a situation in which the outcome of a maker experience does not align with the maker's intentions or the task's goals. While previous research by the research leadership team focused on what contributes to the learners experience around failing or not, this project expanded the focus to include educators and the program supports that contribute to a learners experience of failure.

This report presents the FiM summative evaluation findings aligned with the project's four primary goals (see below) and examines (1) Key Features of the PD Model, (2) Impact on Target Audiences, and (3) Broader Impacts. Data sources include front-end, formative, and summative assessments, an additional study in Year 4 combined with research findings, offering a comprehensive understanding of the project's impact on informal educators and the learning environments in which maker programs were implemented.

2. BACKGROUND

2.1 Project Goals

As science centers, art museums, and other informal science learning (ISE) organizations expand youth-centered maker programs, there is increasing recognition that maker activities inherently involve struggle, iteration, and moments when outcomes do not align with intentions. These moments require intentional, responsive facilitation. Strengthening educators' capacity to provide ongoing, just-in-time support before, during, and after experiences of failure is therefore critical.

The FiM project addressed this need by adapting, implementing, and refining a PD model to support informal educators in productively attending to, interpreting, and responding to youths' experiences with failure in informal STEAM contexts. A distinctive feature of the model was the structured use of video to examine instructional practice. Through collaborative discussion, experiential learning, and reflective analysis, educators engaged in sustained inquiry within professional learning communities. The PD emphasized empathy building, resiliency, risk-taking, and adaptive problem-solving, with the goal of helping educators create environments where youth can navigate challenges, view failure as a learning opportunity, and develop persistence and maker identity.

Building on prior research on youths' experiences with failure in making, the project pursued the following goals:

- Investigate features of the professional development models that best support lead facilitators in supporting informal educators in attending, interpreting, and responding to youths' experiences with failure while engaged in making tasks.
- Investigate changes of informal educators' pedagogical practice around youths' experiences with failures through engaging in the professional development models
- Examine shifts in youths' (a) resiliency and perception of failure and (b) self-perception as a maker.
- Analyze shifts in perspectives on failure and struggle of lead facilitators and informal educators.

2.2 Implementation

The objective of the research was to adapt, implement, and refine a PD program focused on supporting informal educators' instructional practices on ways to plan for and respond to youths' experiences with failure. The aim was to have a positive impact on developing participants' pedagogical practices around failure, as well as developing youths' affinity for resilience during making tasks and a strong sense of self as a maker.

The project was implemented across two cohorts: Cohort 1 (Years 1–2) and Cohort 2 (Year 3), with a focus on iterative improvements and expansion based on the Problem-Solving Cycle model (Borko et al., 2015), see Figure 1 below, a PD model originally designed for mathematics classroom teachers.

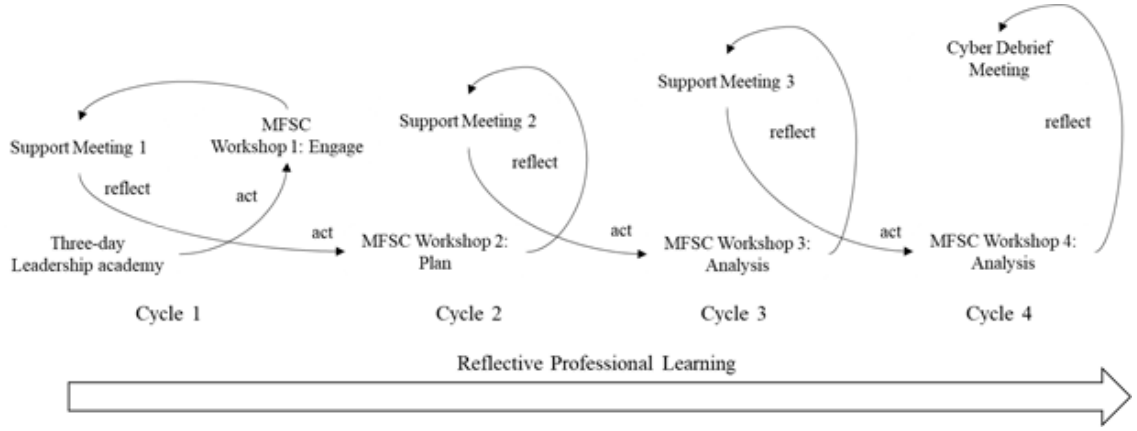
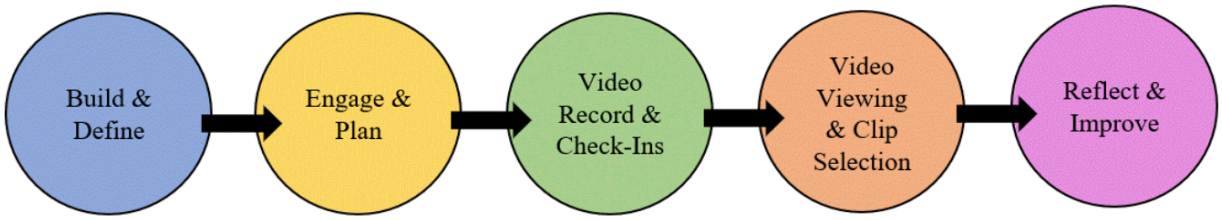


Figure 1: Problem-Solving Cycle Model by Borko and colleagues (2015)

Based on the Problem-Solving Cycle Model by Borko et a. (2015), the FiM project co-developed the following iterative cycle for PD development and implementation including the following steps:



1. Build and Define – Establishing foundational concepts and structuring the PD program.
2. Engage and Plan – Conducting initial training sessions and workshops.
3. Video Record and Check-Ins – Documenting educator-youth interactions during maker activities.
4. Video Viewing and Clip Selection – Analyzing selected footage to assess teaching strategies.
5. Reflect and Improve – Using findings to refine pedagogical approaches and program implementation.

2.3 Partners

During Phases I and II, the project engaged **19 informal science organizations** across two primary groups:

- **Cohort 1 (6 sites)** – Co-developers and early adopters implemented FiM strategies.
- **Cohort 2 (13 sites)** – Expanded group refined best practices.

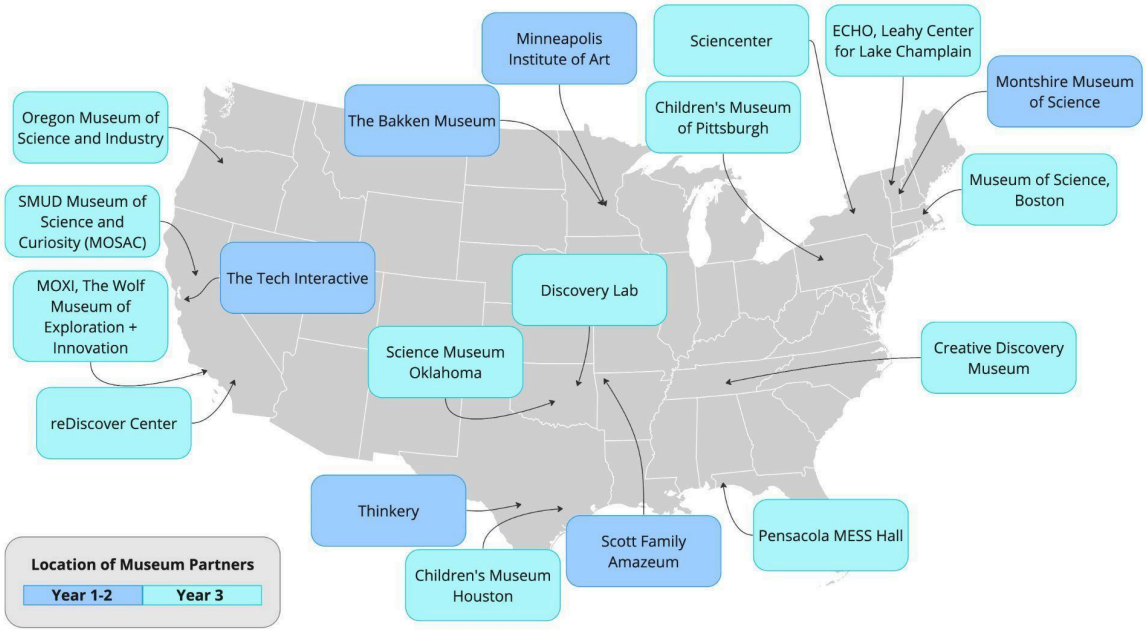


Figure 2: FIM Cohort 1 and 2 Partners across the U.S.

Phase I / Year 1 – Launch of CoP and Adoption of PD Cycle (Cohort 1)

In 2020, the research team launched a CoP with informal educators from six museums across the nation forming Cohort 1. The participating sites included five science centers and one art museum:

- Montshire Museum of Science (Norwich, VT)
- The Bakken Museum (Minneapolis, MN)
- Amazeum (Bentonville, AR)
- The Thinkery (Austin, TX)
- The Tech Interactive (San Jose, CA), and
- Minneapolis Institute of Art (MIA, MN).

Cohort 1 participants included 2–3 lead facilitators from each site, totaling 14 members. Many lead facilitators held dual roles, coordinating programs while also engaging in teaching. While failure in making was not a new concept to these organizations, the sites were selected due to their prior work and expertise in this area. Despite their shared experience in making, each site had a unique combination of institutional size, cultural norms, perspectives on failure, and approaches to implementing the PD model in their museum's programming.

In Winter 2020, the research team launched regular CoP meetings to establish relationships, introduce the project, and explore the concept of failure in making. By Spring 2021, lead facilitators from each site participated in a virtual Leadership Academy, preparing them to train their informal educators for summer camp and other STEAM programs. The team co-developed the Making Failure Leadership Preparation (MFLP) Model and the Making Failure-Solving Cycle (MFSC) Model with Cohort 1, based on Borko et al.'s (2015) problem-Solving Cycle (see Figure 1). The goal of the Leadership Academy training and the subsequent CoP sessions (Workshops 1 and 2) was to engage educators in making activities as learners, develop an understanding of the knowledge and skills required to facilitate the making activity, develop empathy for the learner, and consider times in which youths may experience failures, including how the available material, tools and human resources may lead to experiences with failure. Workshop 2 focused on adapting making programs to address, rather than eliminate obstacles, by developing pedagogical strategies to productively address youths' failures before, during, or after they occur.

In Summer 2021, CoP members trained their educator teams and recorded 1–2 days of making programs during summer camps or other STEAM programs. They selected video clips that were analyzed in Workshops 3 and 4, where educators reflected on pedagogical approaches in response to youths' reactions to failures and how to shift resilience and perceptions of failure.

Following this cycle, sites set pedagogical goals for addressing failure, which would guide their implementation of the next cycle in Year 2. Given the project's feasibility study design, teams iteratively implemented the PD model over two years, allowing for site-specific adaptations. As part of laying the foundation for scaling the PD model in Year 3, the CoP worked toward refining a research-based framework that could be implemented across a new cohort of informal institutions. The overarching goal was to enhance youth resilience and perception of failure during making tasks, with findings disseminated through publications and an online toolkit.

Phase 1, Year 2 – Cultivation of CoP and Adaption of PD Cycle (Cohort 1)

In Year 2, five of the six partnering sites continued in the project: Montshire Museum of Science, The Bakken Museum, Amazeum, The Thinkery, and The Tech Interactive. The Minneapolis Institute of Art (MIA) did not host

summer camps in 2022, and a key staff member overseeing teaching artists and informal educators left the museum. As a result, MIA withdrew from the program in Spring 2022.

The Tech Interactive was the only site to implement the PD program in a workshop setting, shifting from the Year 1 design challenge drop-in model. The CoP continued with 14 lead facilitators, some balancing dual roles in program coordination and teaching. Each museum maintained a unique approach to implementation, shaped by their size, resources, cultural norms, and perspectives on failure.

The research team continued using the Problem-Solving Cycle model (Borko et al., 2015) to refine the PD program. The Spring 2022 Leadership Academy in Minnesota was held in a hybrid format to accommodate ongoing COVID-19 challenges. During Spring and Summer 2022, CoP members trained their museum educators with a revised version of the FiM PD. Each site recorded 1–2 days of making programs. Selected clips were analyzed in Workshops 3 and 4 to examine educators' responses to youth failures and explore ways to foster resilience and shift perceptions of failure. Lead facilitators refined and adjusted their goals during the second PD cycle. The CoP laid the groundwork for scaling the PD model in Year 3.

Phase II, Year 3 – Expansion and Cohort 2 Implementation (Cohort 2)

In Year 3, the research team expanded the project by recruiting new museum partners to form Cohort 2. From a pool of 26 interested organizations, 13 sites were selected to participate:

- Children's Museum Houston, TX
- Children's Museum Pittsburgh, PA
- Creativity Discovery Museum, Chattanooga, TN
- Tulsa Discovery Museum, OK
- ECHO, Leahy Center for Lake Champlain, Burlington, VT
- MOXI, The Wolf Museum of Exploration + Innovation, Santa Barbara, CA
- Museum of Science (MOS), Boston, MA
- MOSAC, Sacramento, CA
- Pensacola MESS Hall, FL
- Rediscover Center, Los Angeles, CA
- OMSI (Oregon Museum of Science and Industry), Portland, OR
- Science Museum of Oklahoma, OK
- Sciencenter, Ithaca, NY

Building on the research-based PD model and online tool co-developed with Cohort 1, the focus in Year 3 shifted toward testing, refining, and scaling the program with this new cohort. This phase involved a structural transistion—from a CoP collaboratively co-developing the PD model to a Professional Learning Community (PLC) engaging in structured training while providing implementation feedback. A guiding question guiding this phase was: How can the online toolkit most effectively support museum partners in developing site-specific PD tailored to diverse educator audiences, including full-time staff, part-time staff, and seasonal educators? The central goal of the PD remained consistent: to strengthen educator's capacity to foster youth resilience and reframe failure as a productive component of making and design processes. Cohort 2 museums were actively engaged in both research and practice-based refinement of the model and supported dissemination findings in multiple formats.

Phase III, Year 4 – Cohort 3

During the no-cost extension year (Year 4), the research team launched two new study groups involving additional sites from the U.S. and Canada as well as museums from Cohorts 1 & 2.

DIY Group

The Do-It-Yourself (DIY) Group included eight sites and aimed to test how well the FiM website supports the PD cycle with minimal interaction from the research team (3-4 meetings per organization). Sites included:

- Children's Science Center (Dulles, VA)
- Discovery Place (Charlotte, NC)
- KID Museum (Bethesda, MD)
- Imagination Station (Toledo, OH)
- Salt Lake City Observatory (Salt Lake City, UT)
- Sloan Longway (Flint, MI)
- Twose (Telus World of Science Edmonton) (Edmonton, CAN)
- Ingenium (Ottawa, CAN)

Adult Learner Study Group

Engaged six museums from Cohort 1 and 2 in developing and implementing an "intervention" study on how informal educators can support parents and other adults during their own and/or their child(ren)'s failure moments. (Aim 2) Participating sites included:

- Cohort 1: The Tech Interactive (CA); Montshire Museum of Science, (VT)
- Cohort 2: Rediscover (CA); OMSI (OR); MOSAC (CA); Museum of Science/MOS (MA)

2.4 Toolkit

A key deliverable of the project was the development of a toolkit/website to share and disseminate effective practices and support museum professionals to conduct PD around supporting failure in youth making programs in informal learning settings like museums and science centers (see FiM project website). Over the course of the project, the research team and Cohort 1 partners drafted and revised a project website/toolkit, iteratively incorporating new lessons learned from literature, research and practice. As the PD was modified and implemented with Cohort 2, the collaborative research team further refined its thinking about the toolkit. The website has been tested by the DIY Group with a minimum of support from the leadership team in Year 4 and is being further modified during a second no-cost extension year to incorporate the feedback from all partner sites, the evaluator and the advisory board.

3. EVALUATION DESIGN AND METHODOLOGY

The summative evaluation assessed the effectiveness of the FiM PD model and the extent to which it achieved its intended outcomes. The final evaluation integrates findings from Cohorts 1 and 2, the Year 4 study, and formative evaluation data collected during Years 1 and 2. Together, these data provide a comprehensive assessment of program implementation, refinement, participant impact, and scalability across institutional contexts.

3.1 Evaluation Questions

Guided by the project logic model (Appendix 5), the summative evaluation addressed the following questions:

- PD Features and Effectiveness – For Cohorts 1 and 2, which features of the FiM PD model did the project team, lead facilitators, and informal educators find most effective in shifting pedagogical practices around youth experiences with failure?
- Impact on Educators – To what extent did participation in the PD and associated learning activities influence the knowledge, skills, and facilitation practices of lead facilitators and informal educators?
- Shifts in Perspectives on Failure – How did the PD contribute to changes in educators' understanding, language, and approaches related to productive failure?
- Impact on Youth Learning Experiences – What evidence suggests that shifts in adult facilitation practices translated into changes in youth engagement, persistence, collaboration, and comfort with iteration?
- Year 4 Supplementary Insights (Cohort 3 / DIY and Adult Study Groups) – What adoption patterns and longer-term impacts of the FiM PD were reported by sites outside the original evaluation plan?

3.2 Participants

The project engaged 27 informal science organizations across three cohorts and three implementation phases:

- **Cohort 1 (6 museums):** Co-development sites and early adopters that collaborated with the project team to design and pilot the PD model; included in both formative and summative evaluation.
- **Cohort 2 (13 museums):** Expansion sites that implemented the PD at scale and contributed to refinement of best practices. Cohort 2; included in the planned summative evaluation.
- **Cohort 3 / Year 4 (8 museums):** DIY sites that independently integrated FiM PD with minimal support; added after the original evaluation plan and included only in Year 4 survey to assess adoption and impact.
- **Adult Study Group (6 museums from Cohorts 1 & 2):** Applied FiM approaches with adults and caregivers; included only in Year 4 survey

Across cohorts, participants included 51 lead facilitators and approximately 160 informal educators. The range of experience of informal educators ranged from 1 month to 23 years.

3.3 Evaluation Approach

A mixed-methods design was employed, drawing on both formative and summative data sources. Formative evaluation (Years 1–2) informed iterative refinement of the PD model during co-development with Cohort 1. Summative evaluation (Years 3–4) examined implementation quality, participant outcomes, institutional impact, and scalability. Cohort 3, including the DIY and Adult Study Group, was added in Year 4; these sites were evaluated only through the Year 4 survey, which was sent to all cohorts to capture longer-term impacts and broader adoption of FiM practices. The evaluator participated as a contributing member of the research team, attending regular meetings and providing formative feedback while maintaining responsibility for independent summative analysis.

3.4 Data Sources

Observations: Observational data were collected from five 90-minute PLC meetings and three summer check-in sessions (2023), as well as video recordings from two participating institutions. An Advisory Board meeting in Spring 2023 provided additional insights into project implementation and strategic direction.

Focus Group Interviews with Program Leaders

A total of 19 semi-structured focus group interviews were conducted with 2-3 lead facilitators from each site. These interviews examined PD implementation, perceived outcomes, challenges, and cross-site patterns. All interviews were digitally recorded, transcribed, and anonymized prior to analysis.

Individual Interviews with Educators

In-depth individual interviews were conducted with 12 informal educators, one from each partnering site, to explore their experiences with the PD, perceived value of the training, and application of FiM resources to their teaching practice. All interviews were digitally recorded, transcribed, and anonymized for analysis.

Final Participant Survey (Additional Year 4 Study)

A summative survey was administered in October 2024 to assess longer-term impacts of FiM on team practices, visitor engagement, departmental culture, and organizational change. The survey was distributed to all participating sites, including Year 4 study partners, with each site submitting a single collaborative response. Open-ended survey questions focused on assessing program impact and broader institutional effects.

Review of Project Materials

Project documentation reviewed included white papers, literature reviews, PD session materials, reflection tools, and drafts of the online toolkit/website. Most data were collected virtually due to pandemic-related constraints, with limited in-person engagement during a leadership meeting and a national conference convening. Summative instruments, including focus group and individual interview protocols, were iteratively refined based on formative evaluation findings to align with the project's logic model and evaluation questions. Observation protocols and reflection prompts further supported contextualized interpretation and interpretation.

Data triangulation across sources and participant groups strengthened validity by incorporating perspectives from the research team, lead facilitators across 19 partnering sites (Cohorts 1 & 2), and informal educators working directly with youth.

3.5 Data Analysis

Qualitative data were systematically coded and synthesized across formative and summative sources to identify cross-cutting themes. Data triangulation across interviews, observations, surveys, and document review strengthened validity and credibility. Findings are reported in aggregate; no personally identifiable information is included.

Interpretation of data was guided by evaluation questions and included considerations of the following analytic prompts:

- How effectively did the PD program and associated resources impact each target audience?
- Which PD features were most effective in supporting shifts in pedagogical practices related to youths' experiences with failure?
- To what extent did participants increase their knowledge of effective strategies for supporting productive failure?
- What strategies did educators use to respond to youth failure moments?
- To what extent did participants modify their pedagogical practices in response to youth failure moments?
- How did the PD-informed programming influence youth resilience and perceptions of failure?
- To what extent did the PD program contribute to shifts in lead facilitators' and informal educators' perspectives on failure (e.g., language, instructional approaches)?
- What value did participation in the PD program provide for lead facilitators, informal educators, and institutions?

3.6 Limitations

Predominantly Virtual Engagement

Due to the global COVID-19 pandemic, much of the project implementation was evaluated virtually. Although digital tools and strategies supported collaboration and engagement, limited in-person site visits may have reduced opportunities for deeper observations of site-based practices and informal learning dynamics.

Challenges in Youth Data Collection

Direct youth data collection proved challenging. Planned educator-led interviews with youth were not feasible due to staffing and time constraints, particularly during summer programming. As an alternative, partner sites gathered informal youth data through observations and simplified tools embedded in programs (see *'Getting Unstuck List'*, Appendix 4). Additional evidence came from lead facilitator focus groups, educator interviews, and video analysis. As a result, youth impact findings rely primarily on adult-reported and observational data.

Staff Turnover

Staff turnover at partnering sites may have affected continuity of implementation, participation in evaluation activities, and institutional memory across project phases.

These limitations are common in multi-site PD initiatives and were mitigated through triangulation and longitudinal data integration.

4. SUMMARY OF FINDINGS

Findings from the summative evaluation of the FiM project are summarized below and grouped into the following three themes: (1) Program Design and Implementation; (2) Impact on Target Audiences; and (3) Broader Impacts. To maintain confidentiality, quotes of the report have been de-identified.

4.1. PROGRAM DESIGN AND IMPLEMENTATION

4.1.1 Project Participants and Timeline

The FiM PD Model and online toolkit were co-created and adapted in collaboration with 27 STEAM organizations over a four-year period. Participating sites included small, medium and large science centers and museums across the U.S. and Canada who successfully adopted and adapted the PD to their site-specific needs and implemented the PD training with informal educators at their respective sites. Each PD module includes curated resources for discussion and reflection, videos, readings, hands-on activities, and practical guidance for using video as a reflection tool and a method for data collection. These tried-and-tested resources are designed to support museum professionals in planning, facilitating and implementing the PD at their own sites. The modular structure of the PD program and online toolkit allows sites to adapt and modify the program to local needs, institutional contexts, and audience populations, supporting implementation across diverse informal learning environments. While Cohort 1 engaged deeply as a CoP over two years providing significant input to the development of the PD modules, Cohort 2 engaged as a PLC to adapt the developed PD modules to their unique needs. Cohort 3 partners implemented the PD via the toolkit with only minimal support from the research team. Together, this provided significant input from practitioners across the ISE field leading to a successful PD model and associated resources.

Summative evaluation findings show that participating STEAM institutions successfully adopted the PD model to support informal educators in facilitating youths' engagement in making activities.

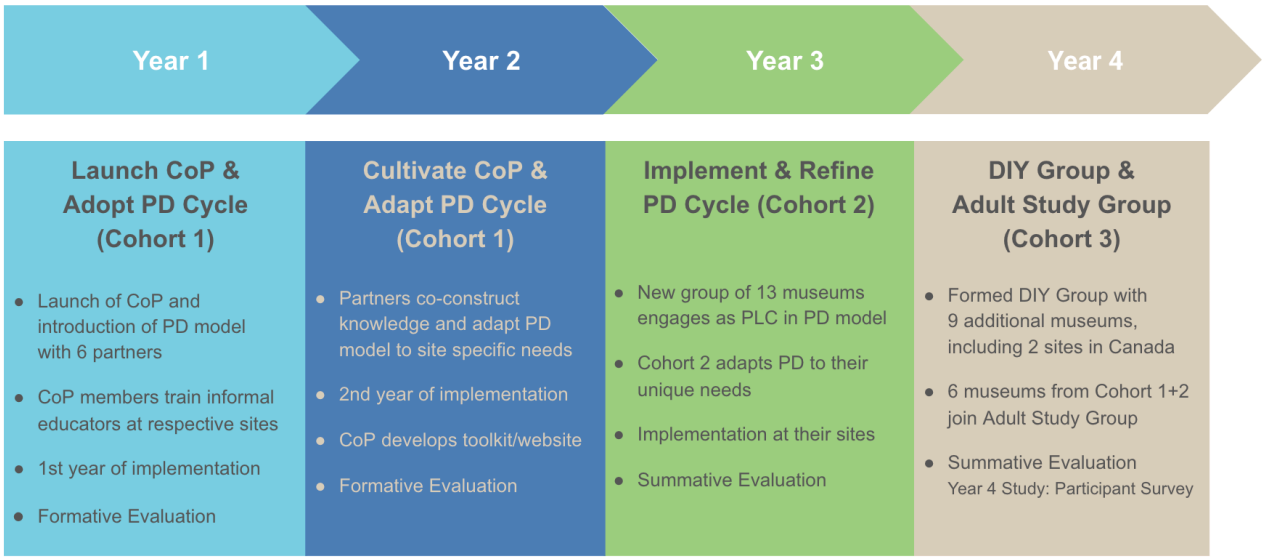


Figure 3: FIM Project Timeline

4.1.2 Key Features of the PD Program

Findings from the final summative evaluation highlight the following features of the FiM PD program as most effective in shifting lead facilitators and informal educators pedagogical practices around youths' experiences with failures during making programs:

- **Putting Research into Practice**
  Co-developed with museum partners across multiple cohorts, the FiM PD translates research on productive failure into actionable strategies. The design integrates evidence-based practices with site-specific needs, ensuring relevance across diverse informal STEAM contexts.
- **Modular, Flexible Design**
  The program is structured as modular, "plug-and-play" components that leaders can adapt to local contexts, educator audiences, and institutional resources. Modules include workshop plans, hands-on making activities, guided reflection tools, and video-based dialogue to support ongoing learning and sustainable implementation.
- **Collaborative Learning Community**
  The PD fosters engagement in a professional learning community where lead facilitators and educators share experiences, reflect together, and provide peer feedback. Structured opportunities for dialogue, mentoring, and collaborative problem-solving enable facilitators and educators to share experiences, reflect collaboratively, and provide peer feedback, fostering shared language and collective problem-solving.
- **Educators as Active Learners**
  Participants engage as active learners in activities, where they experience moments of failure and reflection firsthand. This immersive approach fosters empathy for learners, builds awareness of growth mindset practices, and strengthens facilitation skills, enabling educators to model resilient problem-solving and better support youth during challenges in making activities.
- **Supporting a Culture of Reflective Practice**
  Video recording, observations, guided reflection, and facilitated discussions are embedded throughout the PD to support continuous learning, adaptation, and the development of reflective team practices.

Taken together, these design features provide a scalable, sustainable framework that equips lead facilitators to train educators effectively, translate research into practice, and support adaptive, learner-centered facilitation. The FiM PD program balances fidelity to core pedagogical principles with flexibility for local adaptation, enabling sustainable professional learning and implementation across diverse informal STEAM education settings.

4.2. IMPACT ON TARGET AUDIENCES

4.2.1 Impact on Program Leaders

Data from observations, focus group interviews (Cohort 1 and 2), and Year 4 surveys indicate a strong and sustained positive impact on program leaders across all cohorts. The FiM PD empowered leaders both as educators and as practitioner-researchers, offering a flexible and sustainable PD framework adaptable to site-specific needs. Leaders reported increased confidence, strengthened leadership capacity, and a greater ability to support their educators in facilitating productive failure in maker-centered learning environments. Many leaders expressed a commitment to continuing and expanding the work. Several sites extended FiM PD efforts to additional departments, volunteers, teen interns, and onboarding programs, or reported plans to do so in the future.

Cohort 1: Co-Development and Leadership Growth

Cohort 1 played a foundational role in co-developing the CoP and FiM PD model and iteratively refining it prior to broader implementation. Formative evaluation of the virtual CoP showed overwhelmingly positive feedback. All participants found the CoP valuable, collaborative, and effective in deepening reflection around supporting failure in youth maker programming. They gained professional growth and concrete instructional strategies to support their educators in facilitating productive failure. Interviews with lead facilitators revealed continued positive impact in Year 2. Participants especially valued the in-person convening, noting it allowed them to "*make stronger, deeper connections.*" Immersive experiences where educators engaged in making practices followed by reflections were seen as supportive for gaining empathy for youths' perspective and especially how students feel when things are not turning out as planned. Leaders highlighted the value of shared resources, site-based examples, and access to peer-created materials. As one participant stated, *"some of the most helpful aspects have been access to the resources and videos and things that other groups have done".* Lead facilitators reported the FiM PD increased how prepared and confident they feel in training and mentoring their educators around supporting youths' during moments of failure.

Success Story: ASTC 2024 Pre-Conference Workshop

A major milestone occurred in October 2024, when Cohort 1 leaders independently planned and delivered a full-day pre-conference workshop for 26 participants at the annual Association of Science and Technology Centers (ASTC) conference in Charlotte, NC (see Appendix 1). The train-the-trainer session demonstrated FiM Cohort 2 leaders' strong confidence and skill in (1) introducing the PD model, (2) facilitating hands-on learner-centered experiences, and (3) translating those experiences into effective professional learning for other educators. Their ability to lead independently reflects the program's success in cultivating not only skilled practitioners but also leaders in the field. The impact extended beyond the workshop itself. Several attendees expressed interest in joining the next cohort. One participant later wrote to the research team stating *"This PD cycle is something that we are now trying to implement with our educators".* That organization subsequently applied to joining Cohort 3 (DIY Group), demonstrating the scalability and influence of the PD model.

Cohort 2 – Professional Learning Community (PLC):

Due to high interest, 13 additional ISE organizations joined Cohort 2, exceeding the original goal of nine. The goal of the Cohort 2 activities was to test the FiM PD as a one-year PLC. Participation levels varied. While most

organizations were strong and committed participants, others engaged at a minimum level and experienced capacity constraints related to video documentation and website use. Overall, Cohort 2 experienced fewer technical and implementation challenges than Cohort 1, in part due to the development of a practical video guide, as well as modifications to the PD modules and resources. Compared to Cohort 1, Cohort 2 lead facilitators demonstrated greater clarity in articulating goals and identifying actionable steps. The research team described them as "confident and efficient," with stronger intentionality and clearly defined outcomes.

The summative evaluation found that Cohort 2 participants reported increased confidence as instructional leaders, an enhanced ability to integrate reflective practices to support educator's growth around facilitating failure moments during STEAM activities, and valued the tried-and-tested tools and instructional strategies to translate the PD into practice. Cohort 2 partners especially valued peer learning, mentorship from Cohort 1 leaders, and coaching support from the research team. Although some sites cited limited time and resources to complete the full training cycle, especially video recording, most recognized its value and expressed commitment to sustaining the work. Several organizations began integrating FiM PD into staff onboarding, volunteer and teen training programs, and exhibition floor facilitation. One lead facilitator noted:

> *"We're putting in a couple pieces into the quarterly onboarding training we have for new volunteers … Each time we switch out our interactive floor programs, that's also a chance to infuse some of the facilitation training into the introduction to the new activity and the content of that activity."*

Findings from Cohort 2 reinforced and confirmed impacts observed in Cohort 1, demonstrating the effectiveness, adaptability, and sustainability of the FiM PD model in building program leaders capacity.

Cohort 3 (DYI Group): Independent Toolkit Implementation

Cohort 3 leaders successfully used the online toolkit to plan, adapt, and implement the FiM PD at their sites with limited support from the research team. Despite their shorter involvement, Year 4 survey feedback was overwhelmingly positive. As program leaders from Cohort 3 reported, their engagement in the project led to insights into improving facilitation strategies and building empathy for learners' failure experiences. One Cohort 3 leader described the impact:

> *"Our FiM work has encouraged staff to embrace vulnerability, to recognize opportunities to learn together with staff and museum guests, and to understand the value of collaborating through failure. We have begun and continue to provide safe spaces for guests to fail and receive the support they need to fail forward."*

> *"We have held training sessions to get our staff more familiar with the FiM philosophy, practiced role-playing scenarios, and held brainstorming workshops to help staff approach failure situations and come up with their own solutions for working through challenges with guests. We have incorporated a "Failure Guide" in our make classes as well as in our Standard Operating Procedures. We begin teaching FiM to our staff at onboarding and that work echoes through the experiences we develop and implement on the floor."*

Cohort 3 (Adult Study Group)

Leaders in the Adult Study Group (Cohort 1 and 2 members) explored application of FiM approaches with adults and caregivers. Participating sites reported a meaningful impact on how their teams approached engagement with

caregivers. Participation strengthened understanding of the importance of introducing caregivers to the importance of productive failure and providing role modelling and supportive resources. As one leader reflects:

> *"We now have a better understanding of the effect of introducing caregivers to the importance of failure in play and helping them with resources. Floor staff are observing more carefully how caregivers interact with their child before they intervene/join and focus on working within their "play" style."*

4.2.2 Impact on Practice with Educators

Feedback from focus groups, educator interviews (Cohort 1 and 2), and Year 4 survey data consistently indicates that the FiM PD had a meaningful impact on how program leaders train and support educators. Although implementation varied across institutions, each site successfully adapted the PD model to fit the needs of its staff, setting, and audience. Some organizations integrated FiM into existing PD structures, while others developed stand-alone sessions or hybrid approaches. This adaptability reflects one of the strengths of the FiM model: its flexibility to align with diverse institutional context while maintaining core principles. Feedback indicates that the PD helped leaders cultivate a shared understanding of failure as an expected and productive component of learning. This strengthened their capacity to support educators in interpreting and responding to youths' experiences with failure during making activities. FiM tools, such as the *Failure Buckets* worksheet [see Appendix #], supported leaders in guiding educators to identify and analyze moments of failure and apply insights to their facilitation practices. PD sessions and associated resources increasingly emphasized observation and patience (e.g., wait-time), open-ended questioning, adaptability, and facilitation moves that intentionally support youth before, during, and after moments of failure.

Positive impacts on practice with educators included:

- Integration of FiM principles into PD sessions, seasonal staff training, volunteer and teen intern training, and educator onboarding
- Inclusion of strategies for facilitating productive failure in maker activities, design challenges, after-school programs, and drop-in programs (e.g., continued use of failure-rich activities such as the pipe-cleaner tower challenge for PD and team building)
- Intentional design of "failure-rich" learning experiences
- Increased emphasis on reflective practice and ongoing evaluation, including the use of video, regular debrief meetings, and brief post-program check-ins

Across cohorts, program leaders reported adopting new understanding and awareness when working with educators, including:

- Developed a shared understanding and common language around failure
- Increased awareness of how to notice and respond to moments of failure
- Greater empathy for learners

- Increased intentionality in supporting productive failure
- Increased self-efficacy and confidence in facilitation
- A shift toward more positive views of failure
- Stronger reflective practice

As one Cohort 2 leader summarized:

> *"The Failure in Making project has impacted our team by providing specific tools and language that educators can use during facilitation, as well as strengthening the mindset that it is okay for both educators and students to fail."*

Reflective practice became central to implementation. Teams reported using video recording, structured debriefs, and regular check-ins to discuss teaching strategies and reflect on their practice. One Cohort 2 leader noted:

> *"There's more reflection on teaching strategies that our educators use, with a greater emphasis on meeting after a particular program for a quick check-in on what was effective, as well as more frequent meetings with a larger team of educators reflecting on a recent program series or event."*

Feedback from DIY Group participants was similarly positive, demonstrating notable impact despite their shorter involvement in the project. Participants reported gaining practical tools to improve facilitation strategies and deepen empathy for learners' experiences with failure. One DIY Group leader described immediate application of FiM concepts through staff training, role-playing, and the incorporation of failure-focused guidance into standard operating procedures and onboarding practices.

Overall, feedback regarding changes in practice with educators was consistently positive. Survey responses and qualitative feedback indicate that the PD program influenced how teams work with educators by emphasizing failure as a constructive and integral part of teaching, learning, and reflection on practice.

As one Cohort 2 leader summarized:

> *"The Failure in Making project has impacted our team by providing specific tools and language that educators can use during facilitation, as well as strengthening the mindset that it is okay for both educators and students to fail."*

Across all cohorts, findings indicate that FiM strengthened leaders' professional growth, instructional leadership, and confidence in supporting educators. Taken together, these findings indicate that the FiM PD supported meaningful and sustained changes in how educators are trained, supported, and reflective about their practice, contributing to more learner-centered and resilience-focused facilitation in maker-centered programs. The progression from co-development (Cohort 1), to scaled PLC implementation (Cohort 2), to independent toolkit adoption (Cohort 3) demonstrates the adaptability and scalability of the FiM PD model. Collectively, these findings provide strong evidence that the FiM program successfully built leadership capacity to support informal educators around facilitating youths' engagement with failure during STEAM-related activities.

4.2.3 Impact on Informal Educators

Findings from individual interviews with lead facilitators and educators (Cohorts 1 and 2) and Year 4 survey demonstrate a substantial impact on informal educators' mindsets, pedagogical practices, and institutional culture as a result of participation in the FiM PD. Across participating institutions, FiM influenced how educators understand failure, design learning experiences, and interact with visitors, contributing to a culture of experimentation, iteration, and reflective practice.

Shifts in Mindset Toward Failure

Educators reported a significant shift in how they conceptualize failure. Prior to participation, many described viewing failure as something to prevent, minimize, or quickly resolve. Through engagement in FiM PD, educators came to understand failure as a productive and necessary component of learning. PD Modules 1 and 2 including interactive activities, role-playing scenarios, video reflection, and facilitated discussion, supported educators in developing empathy for learners and recognizing the emotional dimensions of struggle. Educators described increased comfort with modeling vulnerability and acknowledging their own ongoing learning.

Participants reported a more positive view of failure as a learning opportunity, increased self-efficacy and confidence in supporting productive struggle, greater comfort engaging visitors in authentic conversations about challenges, and reduced reliance on "toxic positivity" in favor of validating emotions and encouraging persistence.

Increased Awareness and Intentionality

Educators reported increased awareness about "failure moments" and greater intentionality in how they respond to them. FiM tools and frameworks, such as *Failure Buckets* and the *Getting Unstuck* list, provided shared language and practical strategies to identify, analyze, and support moments of struggle. Across sites, educators described a shift from emphasizing product completion to focusing on learning processes. Rather than intervening to ensure success, educators became more intentional in planning for and leveraging moments of failure.

Key facilitation strategies implemented included:

- Reframing failure as an opportunity for growth and iteration
- Designing "failure-rich" activities that build in low-stakes experimentation
- Scaffolding challenges into manageable steps
- Setting expectations upfront (e.g., normalizing that activities may require multiple attempts)
- Using accessible language such as "getting stuck/unstuck"
- Encouraging reflection on process rather than outcomes

Educators described resisting the urge to immediately "fix" problems. Instead, they encouraged visitors to test ideas, observe results, and iterate. A response from an educators reflects this shift:

> *"One way I encourage experimentation and embrace failure is by simply allowing it to happen, resisting the urge to quickly 'put a band-aid on it.' ... Now, I embrace failure as a valuable learning opportunity."*

Changes in Facilitation Practice

Based on Year 4 survey responses, the FiM program has significantly influenced how informal educators approach failure and interact with visitors, promoting a culture of "experimentation and iteration". FiM principles have been integrated into maker spaces, summer camps, design challenges, afterschool programs and drop-in programs. Through project related PD training and FiM tools and resources, educators have gained effective facilitation strategies and techniques to support visitors in moments of struggle, fostering confidence, agency, and iterative learning. The FiM training has empowered informal educators to engage youth in meaningful conversations about failure, normalizing failure and encouraging risk-taking. Participating sites report about a shift in how their educators engage with visitors as a result of the program. The focus has shifted to be more on process over product. By intentionally designing and planning for failure moments, educators encourage visitors to embrace failure as a valuable part of the learning, rather than avoiding discomfort or promoting toxic positivity.

Changes in facilitation practice included:

- Asking more open-ended prompting questions (e.g., "What do you notice?")
- Validating emotions and modeling self-compassion
- Stepping back to promote learner ownership and agency
- Acting as a "guide on the side" rather than taking over
- Showing intentionally imperfect examples
- Supporting iteration rather than directing toward a single "correct" solution

Educators also reported heightened awareness of how tone, body language, and word choice influence visitor experiences. One Cohort 3 leader noted that staff became more conscious of recognizing and responding to moments of struggle, offering reassurance about the learning process rather than step-by-step instruction.

Reframing Failure as Part of the Learning Process

Participants in the FiM program consistently described a shift in how they understood failure. Rather than viewing failure as the opposite of success, participants came to see it as an essential component of the creative and iterative process. Feedback from educators noted that prior to their participation in FiM, they actively tried to "bake failure out" of activities by designing experiences aimed at predictable outcomes and successful completion. Through the program, participants began to intentionally "bake failure into" the process, recognizing it as a productive moment for reflection, problem-solving, and iteration. In this reframing, failure was described not as a deficit but as an opportunity—"seeing the glass half full"—that prompted educators and learners to pause, reconsider their approach, think beyond familiar solutions, and access new possibilities that would not have emerged otherwise.

Capacity Building and Institutional Integration

FiM strengthened institutional capacity to support productive failure. Many sites extended FiM training to seasonal and part-time staff, embedding shared tools and language across teams. Educators described increased opportunities for collaborative reflection, including role-playing scenarios, MOS charts, and structured team discussions. The PD created space for educators—who often work independently on exhibition floors—to reflect collectively on practice. Participants described becoming more reflective practitioners, intentionally inviting change,

and sharing strategies across departments. Across participating institutions, learning from failure became embedded in making and design programs. Educators reported that FiM contributed to richer visitor experiences by fostering confidence, agency, persistence, and iterative learning.

Overall, findings from interviews and survey data suggest that FiM contributed to sustainable changes in educator mindset, facilitation practice, and institutional culture. By equipping informal educators with tools, shared language, and reflective practices, the program reinforced failure as an integral component of exploration, experimentation, and growth. These outcomes align with the project's broader goals of supporting productive struggle in informal STEAM learning environments and building educator capacity to foster learner agency and resilience.

4.2.4 Impact on Youth/Learners

While the program was not able to conduct learner evaluation as originally planned, observational data and feedback from lead facilitators, educators and the research team suggest a positive impact of participation in the FiM PD on learners/youth. As a result of engaging in the PD, educators reported shifting their practices to emphasize learner-centered maker activities, prioritizing process over product and intentionally fostering youth agency. This shift positioned learners more firmly in the "driver's seat", encouraging them to take ownership of their learning and see themselves as leaders, creators, and problem-solvers. Educators observed that students demonstrated increased independence as facilitators stepped back and encouraged youth to seek support from peers before turning to adults. Rather than immediately asking a facilitator for help, learners were more likely to consult a friend, collaborate, and problem-solve together. (See poster front-loading ideas for what to do when you get stuck: *Getting Unstuck List*, Appendix 4.) This peer-to-peer engagement contributed to a culture where youth took greater responsibility for their learning, especially in camps where youth engage for a longer period of time.

Across interviews, educators consistently highlighted the positive impact their observed on learners, including:

- **Increased agency:** changes in educator practices promoted youth confidence in their own ideas and abilities.
- **Greater independence:** Learners demonstrated increased initiative and ownership over their projects.
- **Enhanced confidence and competence:** Students appear more willing to try new strategies, persist through challenges, and trust their problem-solving skills.
- **Empowerment:** Youth began to see themselves as capable leaders and doers.

Educators also emphasized the importance of creating safe spaces for productive struggle. One educator from Cohort 2 reflected:

> *"I think setting them up for that [failure] in a place that they feel safe and when there's support there if they need it, I think is really valuable to them because it gives them that safe place to experience little failures that are not going to impact their lives in a big way. It's just in the moment and getting them used to it and knowing that it is okay to fail and you are going to fail and it's going to be okay and here's how you work through it. I think that's a really valuable lesson for kids that they don't get a lot of, especially in school."*

4.2.5 Value Creation and the "Ripple Effect" of the CoP

Evaluation findings indicate that the FiM PD program functioned as a value-creation system, supporting change that extended from professional participation to youth learning experiences. Across interviews and surveys, participants frequently described the FiM PD as creating a "ripple effect", beginning with their own learning and extending outward to colleagues, programs, and ultimately youth experiences. The concentric-circle model below (Figure 4) visualizes this ripple effect as layered and interdependent forms of impact.

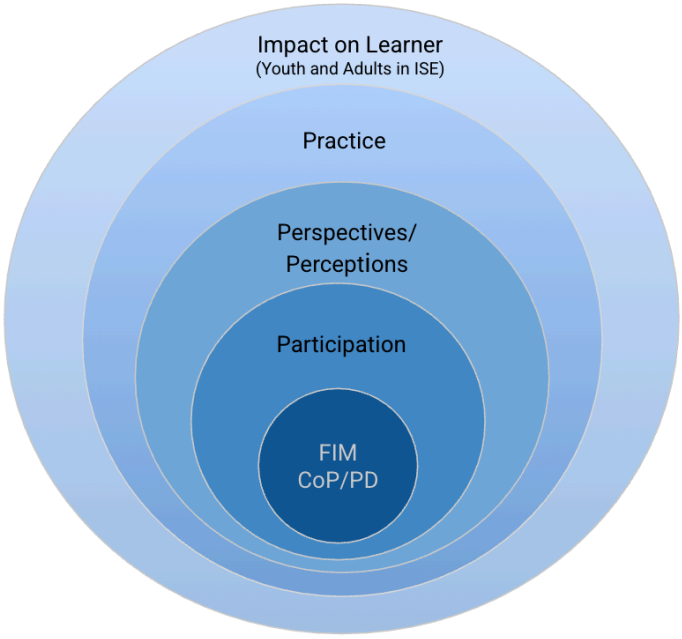


Figure 4: Value Creation of Community of Practice

At the center is the FiM professional learning structure, including the CoP, which provides structured opportunities for dialogue, shared reflection, peer feedback, and collaborative problem-solving. Active engagement in this professional learning network was foundational to experiencing impact. The second circle represents participation in workshops, PLC meetings, hands-on activities, and reflective processes that support professional growth. The third circle reflects shifts in perspectives and perceptions. Participants reported reframing their understanding of failure, from something to prevent or fix to a productive and necessary component of learning. This shift in mindset represented a critical early outcome of the PD. The fourth circle represents changes in facilitation practice. As perspectives shifted, educators reported modifying their behaviors by allowing productive struggle, using reflective questioning, modeling iterative problem-solving, and intentionally designing for learning through failure during making activities. The outermost circle represents impact on youth learning experiences. When shifts in participation, perspective, and practice aligned, educators reported observable changes in youth engagement, including increased persistence, collaboration, comfort with iteration, and resilience during STEAM programs. Together, this model illustrates how the FiM PD generated layered impact - beginning with structured professional learning and extending outward to influence educator practice and youth experiences in STEAM programs. It underscores that impact on youth was contingent upon sustained participation, mindset shifts, and corresponding changes in facilitation practice.

4.2.6 Impact on Departments

Feedback from survey participants of the Year 4 study suggests that the FiM program has impacted departmental practices at participating sites by embedding failure as a focal point for PD training, ongoing reflection, and collaboration. The influence of the FiM PD is evident in cultural shifts, intentional program design, improved capacity, and stronger connections between colleagues and teams within the department.

- All sites see the value in the FiM PD and associated resources and show commitment to continue and potentially expand their effort.
- FiM informed program design, implementation and reflection. Leaders report to be more intentional around how to plan for failure moments before, during and after they happen.
- "Failure is baked in" more in program development, facilitation, and reflective practice.
- Many sites reported adopting and deepening reflective practices inspired by FiM, with intentional conversations around failure becoming part of regular team meetings, program and post-activity reviews. While some sites continue reflection on practice with video taping, most sites do not have the capacity to do so even though they see it as valuable.
- Some participating sites engage educators from other programs within the department, using FiM tools and resources to facilitate discussions around failure in their context.
- Seasonal educators brought FiM principles back to their formal classroom settings, extending its reach beyond the immediate organization.
- Some sites adapted the training and resources for volunteers and teen interns. While still in progress, there is potential for further integration of FiM with volunteers, teen interns, as well as teacher networks.
- FiM outcomes were shared with external educators through workshops, PD programs, and events like Educator Night Out, where resources and tools were distributed. This made FiM participating sites a valuable resource for others around this topic.

Responses from lead facilitators in the DIY Group and in Cohort 2, respectively, illustrate the impact of the program on departmental practices:

> *"Our team of educators has benefitted from this process in multiple ways. They were provided high-quality resources that helped them improve their visitor engagement practices while putting them in the position to remember the feelings of frustration as they worked through new STEAM experiences. This gave one of my staff members his first experience in organizing and presenting trainings to adults. It provided another opportunity for our team to work collegially and vulnerably together. "*

> *"The entire education team (including outreach educators) is more comfortable in discussing failure and growth. Our team has changed the way we engage Summer interns so they are more integrated with the team. They were the primary educators in our Summer PD and reflection series. The experience was so impactful that we've begun to identify projects and PD for interns to use every Summer. "*

4.2.7 Impact on Participating Organizations

Impacts for Cohort 1 and 2

Feedback from Cohorts 1 and 2 suggests that, for many sites, FiM concepts became deeply rooted in organizational efforts and extended beyond individual educators to influence broader institutional practices. Cross-departmental conversations, particularly among education, exhibits, and guest experience teams, laid the groundwork for integrating failure-based approaches across a wider range of visitor interactions. Collaborations with exhibits teams led to stronger incorporation of the engineering/iterative design process as well as explicit failure-related messaging within interactive exhibits. Several organizations also adapted onboarding and internal training processes to include FiM concepts, helping ensure that all visitor-facing staff were prepared to frame failure as a positive and productive part of learning. These changes reflect shifts at the organizational level that support more inclusive learner-centered visitor experiences.

Impacts on the DIY Group

Despite a shorter engagement, the DIY Group demonstrated meaningful participation and notable impacts. Sites in this group recognized the value of the FiM PD and resources, adapted elements of the program to fit their local contexts, and initiated implementation at their institutions. Across DIY sites, there was a strong interest in continuing and expanding these efforts beyond the project period indicating early organization buy-in and potential for sustained implementation. As one lead facilitator from the DIY Group puts it:

> *"In our organization as a whole, we have continued to look into other ways to encourage a growth mindset and acceptance of failure as a part of the workplace. We are interested to see how the industry at large addresses failure and find ways within our organization to improve our processes by embracing failure, taking risks, and trying new things. This mindset has allowed us to have more vocabulary and tools to accomplish organizational goals."*

Overall, findings from the final summative evaluation suggest that longer engagement with the FiM project developed a deeper organizational change, while the DIY model offered a promising pathway for broader participation and initial adoption across a wider range of institutions.

4.3. BROADER IMPACTS

Over the full project period, the FiM project generated sustained broader impacts across research, practice, workforce development, and national field-building. Consistent with the project's original goal "to advance discovery and understanding while promoting teaching, training, and learning," summative findings demonstrate broad impact at institutional, national, and scholarly levels.

Advancing Research and Professional Learning

Across the four project years, the collaborative research team successfully embedded research activities within professional development for STEAM-related making programs in ISE settings. Rather than separating research and practice, FiM integrated structured reflection, documentation, and iterative refinement directly into PD cycles. The

project adopted and adapted a PD framework grounded in the PD model by Borko et al. (2015), modifying it based on iterative feedback from lead facilitators and educators across partner sites. This process ensured theoretical grounding while maintaining contextual flexibility. In collaboration with ISE practitioners, the research team co-developed pedagogical practices to train lead facilitators across the U.S. and Canada. These leaders subsequently trained informal educators at their institutions, including senior educators, seasonal staff, volunteers, and teen interns, demonstrating scalability and distributed leadership capacity.

Building Partnerships Between Academia and ISE Organizations

A central broader impact of FiM was the strengthening of partnerships between university researchers and informal STEAM institutions. The collaboration increased mutual understanding and trust, fostering a shared language across research and practice communities. University-based principal investigators, postdoctoral scholars, graduate students, and undergraduate researchers developed a deeper understanding of museum-based learning environments, institutional constraints, and practitioner needs. In turn, ISE partners gained access to research-informed frameworks, evaluation processes, and sustained professional learning support. The project built long-term relationships of academic institutions with science centers and museums across the country, expanding the foundation for future collaborative research and implementation efforts.

National Field-Building and Cross-Institutional Networks

A key objective of FiM was to design a PD model and toolkit that could scale nationally and broaden participation in research-informed professional learning. Year 4 data indicate that FiM connected leaders from small, medium, and large science centers and museums nationwide, many participating in a national research initiative for the first time. Participants described FiM as a rare opportunity to collaborate across institutions and regions around shared challenges in facilitating productive failure. Notable examples include:

- Cohort 1 leaders independently designed and delivered a full-day pre-conference workshop at the annual Association of Science and Technology Centers conference.
- Strengthened partnerships that extended beyond the grant period, including joint proposal submissions to the Institute of Museum and Library Services.
- Increased regional collaboration among Cohort 2 sites, including ongoing communication and sharing of facilitation strategies.

Across cohorts, participants highlighted:

- The value of engaging in a national research project
- Cross-pollination of ideas and tools across diverse institutional contexts
- Formation of lasting professional networks
- Interest in sustaining collaboration beyond the funded period

These outcomes demonstrate that FiM contributed to national field-building by fostering research-informed professional networks within the ISE community.

Workforce Development: Undergraduate, Graduate, and Postdoctoral Training

The project also made significant contributions to workforce development. Undergraduate students, graduate students, and postdoctoral scholars played active roles in research design, data collection, analysis, PD facilitation, and toolkit development. Through their engagement, trainees gained experience in community-engaged and practice-based research, qualitative and mixed-methods methodologies, co-design with practitioners, translating research findings into practitioner-facing resources, and disseminating findings to both academic and practitioner audiences. These experiences strengthened participants' preparation for careers in STEAM education research, museum studies, informal learning, and applied educational research. The project built collaborative research capacity within university teams, particularly in working effectively with informal STEAM institutions.

Scholarly Contributions and Dissemination

FiM generated numerous scholarly and practitioner-oriented outputs, contributing to both academic research and the ISE field. Dissemination included peer-reviewed journal publications, conference presentations at national academic and ISE meetings, practitioner-focused workshops and field presentations, and public-facing modules and documentation through the FiM online toolkit. Publications contributed to scholarship on productive failure, professional development models, reflective practice, and maker-centered learning in informal environments. At the same time, practitioner-oriented dissemination ensured that findings were accessible and actionable for educators and institutional leaders. The integration of rigorous research with field-based implementation exemplified a strong research–practice partnership model, contributing both to theory development and to scalable, applied solutions.

FiM Toolkit: Sustainable and Open-Access Resource

A lasting broader impact is the development and dissemination of the free FiM online toolkit. Co-created with six initial museum partners and subsequently tested with additional cohorts, including 13 additional museums, and a Year 4 DIY Group, the toolkit provides structured yet flexible modules to support reflective PD focused on facilitating productive failure. Evaluation findings indicate that participants highly valued the toolkit's flexibility and adaptability. Lead facilitators described the modules as a "buffet-style" menu with "plug-and-play" components that allowed them to tailor PD sessions for full-time, part-time, and seasonal educators. Structured reflection tools supported the translation of research-based concepts into daily facilitation practice, helping educators operationalize strategies for addressing youth failure moments.

Ongoing revisions—guided by feedback from partners, the evaluator, and the advisory board—have strengthened usability, accessibility, and organization. Even in lighter-touch Year 4 participation, sites independently implemented core components of the model, demonstrating the toolkit's scalability and sustainability. As an open-access resource, the FiM toolkit extends the project's impact beyond the funded period and supports continued adoption across diverse informal STEAM settings.

4.4 CHALLENGES

Implementation of the FiM PD program across multiple cohorts and institutional contexts surfaced several challenges. While some methodological constraints are discussed in Section 3 (Evaluation Design and Limitations), this section focuses on implementation-related challenges and site responses.

Global COVID-19 Pandemic

The project unfolded during the COVID-19 pandemic, requiring a rapid shift to web-based collaboration, virtual CoP/PLC meetings, and remote PD delivery. Although the virtual format expanded geographic participation and accessibility, it limited opportunities for in-person modeling, informal relationship-building, and site-based observation. Participating sites also noted that youth returned to programs with varied social-emotional needs and learning disruptions, influencing how failure and resilience manifested in making environments. In response, FiM's focus on empathy, growth mindset, and responsive facilitation became particularly salient.

Staff Turnover and Varied Staffing Structures

Significant staff turnover at several institutions, common in informal STEAM education, affected continuity of implementation and institutional memory. Additionally, many sites relied on part-time, seasonal, volunteer, or teen educators with limited onboarding time. These realities highlighted the need for shorter, adaptable PD modules and onboarding resources. Several sites developed or expressed interest in creating condensed versions of FiM training to meet these staffing needs. The modular design of the toolkit supported this adaptation.

Youth Data Collection

Collecting direct youth data proved logistically challenging, particularly during busy summer programming. While this is addressed in the methodology section, implementation revealed an important insight: educators benefited from informal, embedded data collection practices. Sites experimented with simplified observation tools and reflective prompts integrated into programming, for example the 'Getting Unstuck List' asked youth to indicate what strategies helped them most (see Appendix 4). This approach not only generated useful information but also empowered educators to see themselves as practitioner-researchers, strengthening reflective practice.

Time and Resource Constraints

Time limitations and competing institutional priorities affected the degree to which some sites integrated FiM practices into existing programs. In particular, video recording, an intended component of reflective practice, was not consistently feasible due to staffing, equipment, or scheduling constraints. Sites addressed this challenge by using alternative reflection strategies, including peer observation, facilitated discussion, and structured written reflection. These adaptations suggest that while video enhances reflective depth, core elements of the PD can be implemented effectively without it.

Sustaining Momentum Beyond the Program

Several participants expressed interest in maintaining connections with the CoP after formal programming concluded. Sustaining dialogue around failure-related facilitation requires ongoing institutional commitment and structured opportunities for reflection. The open-access toolkit, modular resources, and potential for future

convenings provide mechanisms for continued engagement. However, long-term sustainability depends on institutional leadership prioritizing reflective practice within existing professional learning structures.

Adapting to Diverse Institutional Readiness

Institutions varied in their readiness for reflective practice and in their goals for youth programming. Some sites reported the need for shorter, introductory modules tailored for volunteers, seasonal staff, or teen educators. Others sought deeper engagement aligned with broader departmental goals. The flexible, "make-it-your-own" design supported adaptation across these varied contexts. Several sites created modified versions of the PD to align with local priorities, demonstrating both the demand for customization and the utility of the modular framework.

Overall, these challenges underscore the complexity of implementing multi-site professional development in informal STEAM education. They also highlight the importance of flexibility, modular design, and sustained leadership support in achieving scalable and sustainable impact.

5. DISCUSSION AND RECOMMENDATIONS

The final summative evaluation confirms the strong and sustained impact of the FiM PD model across participating informal STEAM institutions. Leaders and educators consistently reported professional growth, strengthened facilitation practices, and a reframing of failure as an intentional and productive part of learning. A central outcome of the FiM model was a conceptual shift: participants moved from attempting to eliminate failure to intentionally designing for it, influencing facilitation strategies, team culture, and program goals. The cohort-based CoP structure was central to these outcomes. Even sites with shorter engagement (e.g., DIY participants) demonstrated meaningful adoption of core principles, underscoring the flexibility and scalability of the FiM model. FiM also strengthened leaders as change agents, enabling replication of effective practices and embedding failure-rich experiences into institutional norms. At the same time, cross-site findings highlight conditions that influence sustained implementation and scale.

5.1 Sustaining Professional Learning in Informal STEAM Education

Educators across sites frequently described feeling underprepared, under-supported, and professionally isolated prior to participation. The FiM PD model provided structured time and space for collaborative reflection and peer learning—elements educators identified as essential to their growth. These findings underscore the need for sustained, structured PD models that include protected time for collaboration, reflection, and coaching. One-time workshops are insufficient to shift facilitation practice or institutional culture. High levels of staff turnover, particularly among seasonal educators, volunteers, and teen interns, further reinforce the importance of sustained professional learning structures. Turnover disrupts shared language and institutional memory, placing gains at risk without intentional onboarding and continuity structures.

To strengthen institutional resilience, PD models should be continuous and tiered. In addition to comprehensive training cycles for core educators and leaders, STEAM institutions would benefit from supplemental, shorter modules designed for seasonal educators, volunteers, and teen interns. These modules can introduce shared

language, core facilitation strategies, and practical tools for supporting productive failure, ensuring coherence across staffing cycles. Sustained impact also requires structured onboarding materials, peer mentoring systems, documentation practices, and cross-site educator networks that reinforce community and reduce isolation. Embedding these supports within institutional infrastructure strengthens long-term capacity and ensures that productive failure practices remain embedded despite staffing fluctuations.

5.2 Aligning Pedagogical Goals with Institutional Structures

Although making and tinkering programs have expanded across museums, a disconnect persists between pedagogical aspirations and operational realities. Educators often experience pressure to prioritize visitor satisfaction and finished products, reinforcing product-oriented definitions of success. Maker-centered learning, however, emphasizes experimentation, iteration, and open-ended exploration. This tension reveals a broader systemic gap: institutions may prioritize creative learning environments without fully investing in the infrastructure, staffing stability, and backend supports necessary to implement them effectively. A key lesson emerging from the evaluation is that failure cannot be reframed unless success is clearly defined. Institutions are encouraged to explicitly examine:

- What counts as success in maker-centered learning?
- What constitutes productive versus unproductive struggle?
- How are process-oriented goals communicated to staff and visitors?

Aligning expectations, staffing capacity, and resource allocation with process-oriented learning goals will strengthen implementation fidelity and educator confidence.

5.3 Expanding Equity and Inclusion in Conversations About Failure

While participants embraced the idea of "baking failure in," the evaluation also surfaced important considerations around equity. Not all learners experience failure as equally safe. For individuals navigating disability, chronic illness, economic precarity, language barriers, or systemic marginalization, failure may carry additional weight. Future PD efforts would benefit from more explicit attention to: (1) Exploring how failure intersects with identity, access, and power, (2) Designing inclusive and accessible maker environments, and (3) Engaging underrepresented communities in defining what failure and success mean in their contexts. Integrating equity-focused modules and diverse perspectives would deepen the inclusivity and cultural responsiveness of the PD model.

5.4 Sustaining Momentum Beyond the Grant

Year 4 findings demonstrate strong interest in sustaining the FiM CoP. Participants expressed commitment to continuing and expanding the work within and beyond their institutions and emphasized the value of peer exchange and shared reflection. As a Cohort 2 leader stated:

> *"I feel like we've still just touched the tip of the iceberg, and we'd be really interested in continuing if there's ways to asynchronously continue the conversation or participate in some ongoing, an ongoing way."*

While the FiM toolkit is intentionally designed to function as a standalone resource that institutions can adopt independently, evaluation findings suggest that light-touch CoP supports—such as informal gatherings at conferences, periodic virtual check-ins, regional meetups, or peer-led discussions—may enhance continued engagement, reinforce shared language, and strengthen sustained impact over time. Low-cost, distributed CoP structures could help maintain relationships built during the grant period, provide space for ongoing problem-solving, and support adaptation of FiM principles to new contexts. Continued updates to the online toolkit and opportunities for participants to share case examples or emerging practices would further reinforce community learning. Interest from seasonal educators in applying FiM principles in formal classroom settings also suggests opportunities for broader dissemination through conference presentations and cross-sector dialogue.

6. CONCLUSION

The final summative evaluation, integrating findings from Cohorts 1 and 2, as well as the Year 4 study (Cohort 3), and formative data from Years 1 and 2, confirms that the FiM PD model is an effective and adaptable approach to professional learning in informal STEAM education. By integrating research-informed content, reflective practice, and a cohort-based CoP structure, FiM strengthened leadership capacity, shifted pedagogical mindsets, and supported sustained changes in facilitation practice. Across 27 museums and multiple levels of engagement, the model demonstrated scalability and flexibility, with even lighter-touch participation resulting in meaningful adoption of core principles.

Evaluation findings indicate that FiM builds capacity by empowering program leaders as change agents and enabling sustained replication of research-based practices across informal STEM settings. FiM's impact extends beyond practical tools, cultivating educators and leaders who embed productive failure into institutional norms and program design. Although direct youth data were limited, sites reported positive learner outcomes—greater persistence, collaboration, and comfort with iteration—indicating that shifts in adult facilitation fostered more resilient, reflective learning environments.

The project aligns strongly with AISL priorities: maximizing strategic impact through multi-cohort implementation, enhancing knowledge-building via formative and summative evidence, promoting innovation through the PD framework and online toolkit, advancing collaboration, strengthening leadership capacity, and broadening participation across diverse educator audiences. As an Innovations in Development project, FiM created PD models, a toolkit, and resources designed for sustained use beyond NSF funding.

Sustained investment in structured, collaborative PD models like FiM has strong potential to strengthen educator practice, enhance learner experiences, and advance maker-centered STEAM environments that intentionally design for iteration, resilience, and deep engagement.

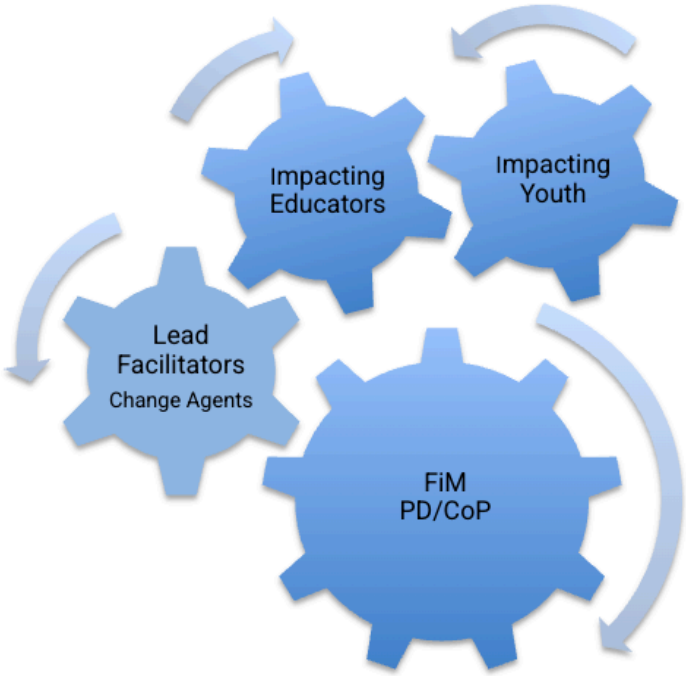


Figure 5: Empowering change agents: FiM PD/CoP drives impact from facilitators to educators to youth.

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Appendices

Appendix 1: Cohort 1 Workshop Presentation, ASTC, Charlotte, 2023

Appendix 2: Quotes from FiM Participants across Cohorts

Appendix 3: 'Failure Bucket Worksheet' created by Amazeum for Workshop 3 and 4

Appendix 4: 'Getting Unstuck List' (Montshire Museum of Science)

Appendix 5: FiM Project Logic Model

Appendix 1: Cohort 1 Workshop Presentation, ASTC, Charlotte, 2023

ASTC Conference, Charlotte, 2023

Pre-Conference Intensive:
Empowering informal educators to support learners during moments of struggle in making and tinkering activities

Cohort 1 hosted full-day highly interactive Intensive Pre-Conference Session with 37 participants (see photo slides)



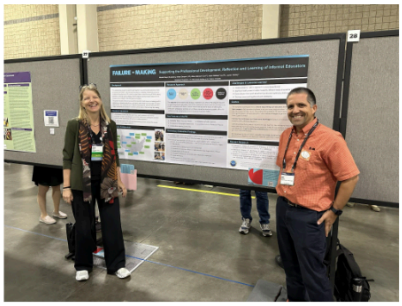
"I keep returning to my notes from the ASTC workshop because your organizational approach and model seemed so streamlined!"
- Feedback from Pre-conference Participant

This was one of the best most interactive PD sessions I've ever been too! Well done!

Thank you for your vulnerability, generosity, strong planning, fun attitudes excellent work!

You guys rocked at sharing your experiences and creating a safe space!





"I am still glowing over my first ASTC conference nearly a month ago! Over the last year, getting to navigate failure with these amazing humans has been enlightening and motivating. Being a part of this group has truly created friendships and transformed how I understand the impact of our spaces. Our Pre-conference full day intensive was rewarding to see this work come so far and reach so many more people. Looking forward to seeing the next evaluations!" - LinkedIn Posting from Cohort 2 Leader Katy Daniel - Thinkery

Appendix 2: Quotes from FiM Participants across Cohorts

Overall Experience

"It was a joyful and deeply moving experience to share connections with like-minded professionals working towards similar missions."

- Leader, Cohort 1

"The word that is coming to mind is, we are empowering our educators to then empower their campers. And, somehow that frame is so much more productive than "I don't know how to fix it. So I'm bad." It's like, no, no. This is about failing forward. It's about saying it out loud that this is gonna happen. We are looking for it. And here are strategies to get out of it."

- Leader, Cohort 1

"Being able to look over my own experiences from a more external and objective lens has given me a much better picture of what I struggle with as an educator versus what I have down pretty well, and what I should pay more attention to trying to change. I think that will be really valuable moving forward."

- Educator, Cohort 1

View of Failure and Shift in Perspective

"I feel like you can't properly learn without failure. Really. One of the big things they did teach us in school is the idea of scaffolding and the idea of when you're working with early childhood educators, you want to be there to help kind of prop them up, but you also have to let them make it on their own. You know, you can't be doing everything for them. You have to let them fail cuz that's how they figure out how things work, how things don't work, that sort of thinking. So it's by far one of the most important parts of learning in my eyes."

- Educator, Cohort 1

"I definitely started thinking about it more while I was teaching, like noticing my language around it and how I react and noticing the student reactions a little bit more since we just talked about it. I just started kind of paying attention a little bit more to that particular aspect of the field trip lab. "

- Leader, Cohort 1

"I feel like this project really helped galvanize my view of failure as just another learning tool. Sometimes you do fail and that is part of learning. In fact, in some ways it's so good that it should be celebrated because it means you get to learn something new and something better and you're just that much closer to getting it right. But yeah, I definitely used to think of failure as a very bad thing, but now it's just a stop on the journey. And I think that's really relevant in making experiences. "

- Educator/Coordinator, Cohort 2

"I think that culturally, especially in the United States, but also in the digital age, delayed gratification is something that kids and people in general don't have as much experience with as they used to. ... I think it's helped us reframe what success in this space looks like. ... I really feel like this has redefined what some of our programming is going to look like going forward because success looks different when you redefine failure."

- Educator/Coordinator, Cohort 2

"I felt like if the kids saw us fail as educators, it kind of gave them a little more confidence that we're not perfect, we don't have all the answers, and we're still constantly learning alongside them every day."

– Educator, Cohort 2

"I do think it has shifted our thinking into thinking in more terms of resilience. We really focus a lot on perseverance. It's one of our innovative mindsets. Resilience is hard since we have a very small time of interaction, but it has helped us to kind of think with our educators on what ways we can boost resilience as well as perseverance in our learners."

– Leader, Cohort 1

"So I feel basically the impact was like we saw ourselves and how we felt about failure, and we don't want these generations to feel that same way. And so we want to model that failure is okay, and that failure is kind of just one way of learning, and it's okay to fail."

– Educator, Cohort 2

Using Video Reflection as a Professional Development Tool

"I think the most valuable part for me, as vulnerable as it was, was watching our clips back together as a group and talking about it. A lot of my colleagues, we all come from such different backgrounds and we all have different knowledge and things, and so hearing other people's perspectives and what they did, what they would've done was really valuable. And I was taking notes and I was like, oh, I really like that strategy. I'm going to try that in my next facilitation. I just feel like we can learn so much from each other."

– Educator, Cohort 2

"And so being recorded, it was that moment of, okay, now I get to sit here and focus on these couple of kids right here and actually pay attention to how I'm interacting with them. So it gave me the space that I needed to just think and realize how I'm dealing with their failures. Whereas before, when you're not really focused on it, it's hard to recognize how you're reacting to kids and to their issues that they're having."

– Educator, Cohort 2

"I think what really happened in that reflective video is that we all kind of fessed up to the things that we're maybe not so good at. That in general is just being a bit more self-aware to become a better team in general."

– Educator, Cohort 2

"So choosing clips that were bad was a really vulnerable moment and helped me to become closer with the staff as well. And also to see them in their vulnerable moments and see that everybody's going through the same stuff was really cool. ... Reviewing it personally first and then bringing it to the group and then having everybody review it with you was really helpful."

– Educator, Cohort 2

"I really enjoyed it [the video recording and reflection on practice]. I thought it was very scary at first just because I think everybody's knee jerk reaction to failure is embarrassment and vulnerability and the idea of being observed by your peers and we're all talking about it and discussing how do we fail or what can we do better and different was scary, but it's been 100% a positive experience. Even just opening up those channels of communication with my colleagues, it's provided more outlets for encouragement, recognition of, oh, I like what that person is doing. I want

to do that too.... It made me feel super prepared and supported actually. It made me feel prepared in the sense that I felt more confident dealing with when things didn't go the way that I was even expecting it to do."

– Educator, Cohort 2

"Our department is now planning to use video recordings as part of our ongoing training (giving/receiving feedback) for ourselves and seasonal staff."

– Leader, Cohort 1

Impact on Practice with Visitors / Effective Strategies in Supporting Learners

"I think I am really just more actively thinking about failure and how my students and my campers might see it. With this project, it got me thinking more of when I'm planning something, how will I get them unstuck while it's happening in this particular project? Like working through my notes as I write the guide for a project or an activity, thinking in that moment, how are some ways that they might fail at this and how can I help them while that's happening? So preparing myself before I even get to the kids."

– Educator, Cohort 1

"I learned new techniques and I have more knowledge of what to do in those kinds of situations."

– Educator, Cohort 1

"There's value in just supporting the feelings, validating it and then trying to encourage this idea that it's normal and it's reasonable and it's just gonna keep happening. So where can we go from here? What's our next step? What can we think about?"

– Educator, Cohort 1

"I think it helps me SO much in my teaching style, learning how to break it down into steps and how to read when a kid needs a break, when they need to be directed towards this idea or if they're getting really stuck, how to guide them towards a few different options for solutions, without straight up giving them the answer. So I think that has really helped me."

– Educator, Cohort 1

"I definitely have worked hard on creating space for kids to have big feelings about failure. Actually another thing that I'm working on incorporating into regular practice that I saw a kid write down two weeks ago was a note to herself that said: 'Sometimes it feels like you are the only person who ever fails at anything, but other people just hide it better.'"

– Educator, Cohort 1

"One way I encourage experimentation and embrace failure by simply allowing it to happen, resisting the urge to quickly "put a band-aid on it." Prior to the FiM Program, I often leaned too heavily on positive reinforcement and tended to overcompensate with praise. Now, I embrace failure as a valuable learning opportunity. Even if I anticipate issues with a visitor's design before they test (e.g., it won't fit inside the rocket or it's falling over), I encourage them to test anyway so we can observe the results together and brainstorm ideas about how to change their design."

– Educator, Cohort 2

"In our classes and workshops, iteration has often played a large role in the design process in the past, but we were not actively training our staff to recognize guest behavior during iteration or underscore the importance of it. We were collectively pushing guests to finish their projects and missing out on valuable teaching opportunities. We regularly had guests getting frustrated with their projects and giving up. Now that our staff is more familiar with recognizing these moments and seeing them as an opportunity to teach, we're seeing many more lightbulb moments in our guests."

– Leader, DIY Group

Leaders' Confidence and Ability to Support Educators

"The thing that prepared us and made us feel most confident working with our educators was the times where we got to talk a little more about pedagogy and language. … Also having the opportunity to help each of them help each other with their growth mindset, by being able to show video and talk about the things that are happening and their language and how they felt about it. And then the facilitators being able to give that kind of feedback was extremely powerful for us. So I do feel like those aspects of the training definitely set us up for success in that way."

– Leader, Cohort 1

"It helped me personally in my interactions with guests and children, but also with my ability to help train staff as well."

– Leader, Cohort 2

"I think that the whole discussion around failure was a really cool one to have with the educators because it isn't something that I feel they've focused on before. And I think that receiving the training from the group did a hundred percent prepare me for that discussion and give me a lot of tools that could be used in those discussions."

– Leader, Cohort 2

"This was a good kind of reset for me and a reminder about building those early scaffolds and that structure and how I sometimes will get ahead of myself in assuming that people have this awareness or ability or comfort in thinking about failure and talking about failure. … The whole thing was an important reminder and eyeopening of where our educators are in their own journey of associating with failure."

– Leader, Cohort 2

Impact on Informal Educators

"Not only did they [informal educators] develop empathy for the learner and the failure experience, but also I think there was in some ways the most valuable part of it from my perspective was the empathy built within the team, the appreciation for trying to work with the public in this particular setting, which we hadn't really explored yet."

– Leader, Cohort 2

"It changed me and my work in the space to gear me away from coddling and more towards productive struggle. …

I think in general it's reminded me to remain open-minded about outcomes in general. … "It's made me a more patient person."

– Educator/Coordinator, Cohort 2

Impact on Team

"I think that it made us more cognizant of each other's facilitation styles and what we bring to the table. ... I feel like I learn a lot from my team members and my team members can also absorb what I bring to the table. I think that it was a great process to get us all on the same page and thinking about how we can really make this a really good experience for different guests and different types of learners."

- Educator, Cohort 1

"I think it offered a new perspective ... I think it made people consider more about the impact they have. I've had some of my colleagues say that, oh, something I say to this eight year old, he's going to remember in five years. It's like, yes, they will. They remember a lot of things. So I think that gave a lot of perspective to our group, to our team."

- Educator, Cohort 2

"I definitely think that it's helped really redirect our vision for the space altogether because we've worked from this same template and it works, it has success, and we intend to use those videos internally for training new staff members coming into the space with this reframed thinking around what failure is and what success is and how we coach kids through making without taking over. Yeah, I think it's really given us a unified experience and toolkit to draw from."

- Educator/Coordinator, Cohort 2

"There's more reflection on teaching strategies that our educators use, with a greater emphasis on meeting after a particular program for a quick check-in on what was effective, as well as more frequent meetings with a larger team of educators reflecting on a recent program series or event."

- Leader, Cohort 2 + Adult Study Group

"This project impacted our team in several ways. Overall, it made clear to us the value of focusing more in-depth on a specific aspect of the visitor experience at Design Challenges. We were aware that failure occurred in our space but had never spent time training educators on how to facilitate those moments specifically, which we now see is quite valuable. While the multi-session professional development workshop was very meaningful and productive for the educators who participated, we've also been able to successfully run two versions of the training for volunteers and interns which has enabled us to incorporate conversations around failure more fully into our In-Gallery Learning program."

- Leader, Cohort 2

Impact on Team / Practice with Educators

"We now have a better understanding of the effect of introducing caregivers to the importance of failure in play and helping them with resources. Floor staff are observing more carefully how caregivers interact with their child before they intervene/join and focus on working within their "play" style. "

- Leader, Cohort 2

"After our participation, we have had many more conversations about failure in floor activities. We've sought to identify moments for constructive failure that can be baked into the activities, but have also had more discussions about frustrating failure and alleviating the instances where it occurs. The "Getting Unstuck" chart has been a great

resource for staff and volunteers to talk with guests about problem-solving strategies that extend outside of our programming. As a manager, I have embraced failure as a way to discuss growth. It has helped team members feel comfortable with imperfection, and allowed us to dive deeper into conversations with an improvement lens and comfort with ambiguity. We are also developing training sessions around engaging with failure."

– Leader, Cohort 2

"Our FiM work has encouraged staff to embrace vulnerability, to recognize opportunities to learn together with staff and museum guests, and to understand the value of collaborating through failure. We have begun and continue to provide safe spaces for guests to fail and receive the support they need to fail forward.

We have held training sessions to get our staff more familiar with the FiM philosophy, practiced role-playing scenarios, and held brainstorming workshops to help staff approach failure situations and come up with their own solutions for working through challenges with guests. We have incorporated a "Failure Guide" in our make classes as well as in our Standard Operating Procedures. We begin teaching FiM to our staff at onboarding and that work echoes through the experiences we develop and implement on the floor."

– Leader, DIY Group

"In our classes and workshops, iteration has often played a large role in the design process in the past, but we were not actively training our staff to recognize guest behavior during iteration or underscore the importance of it. We were collectively pushing guests to finish their projects and missing out on valuable teaching opportunities. We regularly had guests getting frustrated with their projects and giving up. Now that our staff is more familiar with recognizing these moments and seeing them as an opportunity to teach, we're seeing many more lightbulb moments in our guests.

A recent example of this was during a Renewable Energy Wind workshop. Guests build a propeller for a turbine and see if their design can effectively generate enough wind energy to power a lightbulb. A younger guest, around 6 years old, made multiple iterations, but each iteration failed. He got visibly frustrated and upset when he saw his older brother's propellers work while his did not. Our staff intervened by teaching the young guest about propellers – how and why they work. They discussed the importance of functional design, angles and air resistance, and shared examples of propellers that worked versus ones that did not. Without doing the project FOR the child, they gave them ideas to help push them in a new direction. The very next iteration that the child tried was successful and the guest was not only happy with their creation but was able to learn through their failed iterations."

– Leader, DIY Group

"Failure is something I would mention, but since the study, I've integrated it into my training with more care. I'm also preparing to give a class to teacher candidates and intend to do a module on failure and how to teach handling it."

– Leader, DIY Group

Impact on Department

"Our team of educators has benefitted from this process in multiple ways. They were provided high-quality resources that helped them improve their visitor engagement practices while putting them in the position to remember the feelings of frustration as they worked through new STEM experiences. This gave one of my staff members his first experience in organizing and presenting trainings to adults. It provided another opportunity for our team to work collegially and vulnerably together." – Leader, DIY Group

"Our participation has changed how we nurture instructor growth and how we treat the word "failure." It opened a dialogue of permission to fail and try new things. We're also considering expanding to formal teacher PD, in particular in the context of teaching coding.

The program was a good experience overall, and we're excited to do more with it. It has great potential to support our team's development."

- Leader, DIY Group

"Long term, the intensive focus on how adults engage with our Weekend Family Crafting program will contribute to increased attention on how adults engage with all of our programs, including chaperones at field trips, teachers we work with in schools, and parents we engage at community outreach events. While our mission and focus remains on youth STEAM education, this study has helped us to understand the importance of serving adults, both for their own benefit and so that they can better support the youth they work with, and gives us tools that help us to help those adults be more playful, failure-positive, and engaged with hands-on maker activities."

- Leader, Cohort 2 + Adult Study Group

"The language of FIM was really helpful for my team. The way that FIM was structured, the wording used to describe what we were doing and why, has been very helpful. This has made it easy to lead discussions about self-reflection and professional development in a more positive and clear path."

- Leader, Cohort 2

"This was the first training series we did as a newer team, and initiated more regular and structured team trainings. FiM will continue to be a part of that, but it also just bolstered and showed the importance of regular deeper trainings. Culturally, I think our EDU department is also very comfortable sharing the failures and using a hive brain of a creative team to help solve problems together.

Failure feels much more normalized as a departmental value. It doesn't feel like a "dirty" word to the 5 staff members who went through it, which includes leadership, and I think that trickles down to forward facing staff that didn't go through the program."

- Leader, Cohort 2

Mentoring and Training New Staff and Volunteers

"I will say that something I hadn't at least thought through that came up as being a benefit of this was that we have a model where our educators are also training new staff members, volunteers, and interns. And we talked a lot in our last workshop about how we felt like this experience made us better mentors, which is what we call people who are training others, in that they had a new understanding of some of the choices they were making that were working well, and that enabled them to better support other people in making similar facilitation moves that they otherwise had never considered, even though they were doing them."

- Leader, Cohort 2

"The entire education team (including outreach educators) is more comfortable in discussing failure and growth. Our team has changed the way we engage Summer interns so they are more integrated with the team. They were the primary educators in our Summer PD and reflection series. The experience was so impactful that we've begun to identify projects and PD for interns to use every Summer."

- Leader, Cohort 2

Impact on Organization

"In our organization as a whole, we have continued to look into other ways to encourage a growth mindset and acceptance of failure as a part of the workplace. We are interested to see how the industry at large addresses failure and find ways within our organization to improve our processes by embracing failure, taking risks, and trying new things. This mindset has allowed us to have more vocabulary and tools to accomplish organizational goals."

- Leader, DIY Group

Connecting with other Professional in the Field

"I have further connected with neighboring states' cohorts from this project. Many of the museums participating are colleagues I have collaborated with before, but to speak with them on a deeper level about failure and its necessity to the learning process has been extra special. We certainly got closer, and collaborating with those museums afterward has been easier."

- Leader, Cohort 2

Sustainability of the FiM Program

"I think this is a great ongoing practice that we will be able to continue to do in the future. ...To me, it seems like it's very much about mindset. It's very much about reframing the way that we're interacting and redefining success and redefining failure and how to best approach it.

I think this could be a really valuable process for other departments in our museum as well. So I know personally I would continue to use it in the same way because I think even if you've been through this training, I think it would still be valuable to revisit it annually or something, but I could definitely see it expanding into other parts of our education department."

- Leader, Cohort 2

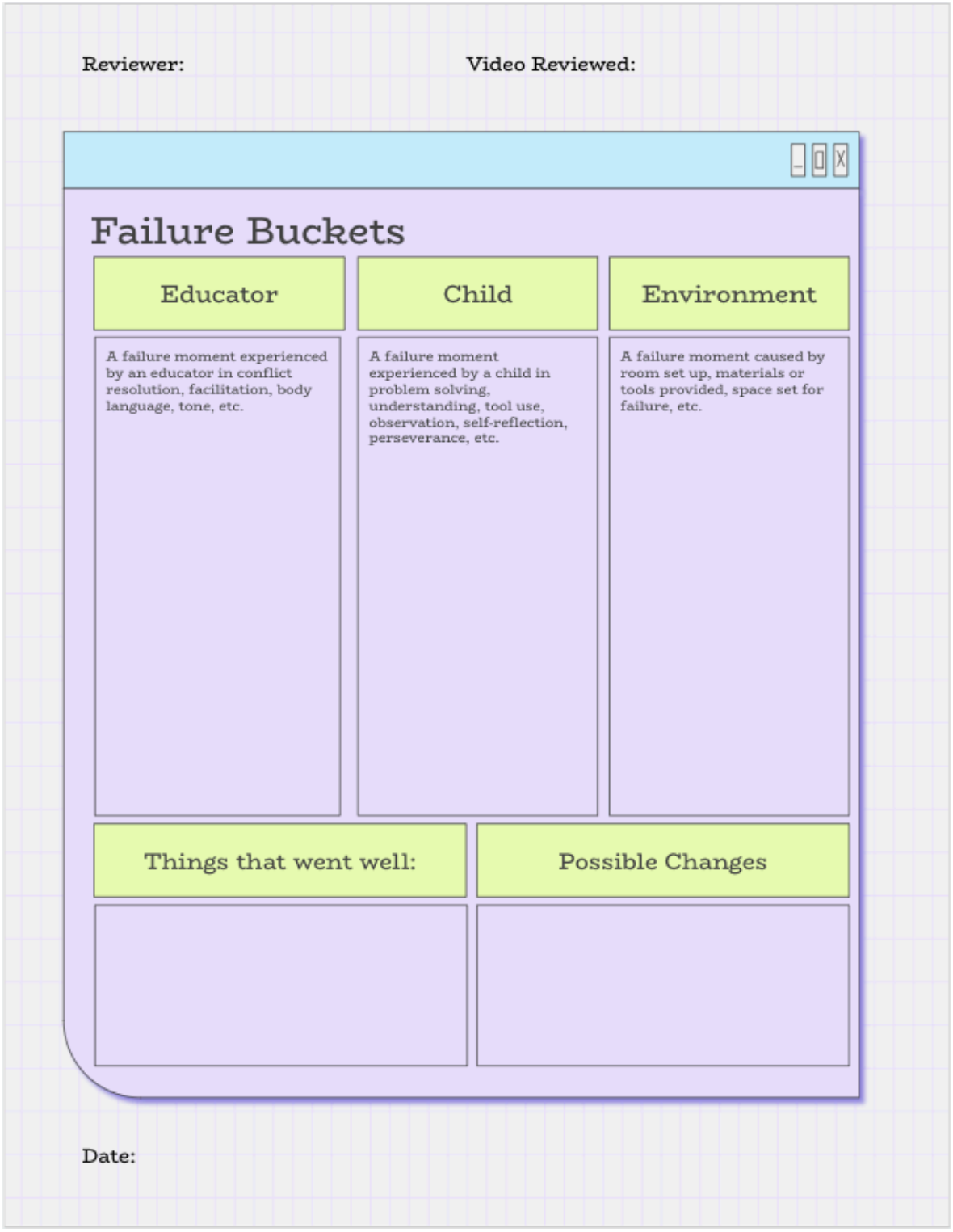
Desire to Continue the Community of Practice

"I feel like we've still just touched the tip of the iceberg, and we'd be really interested in continuing if there's ways to asynchronously continue the conversation or participate in an ongoing way."

- Leader, Cohort 2

Appendix 3:

'Failure Bucket Worksheet' created by Amazeum for Workshop 3 and 4



Reviewer: Video Reviewed:

Failure Buckets

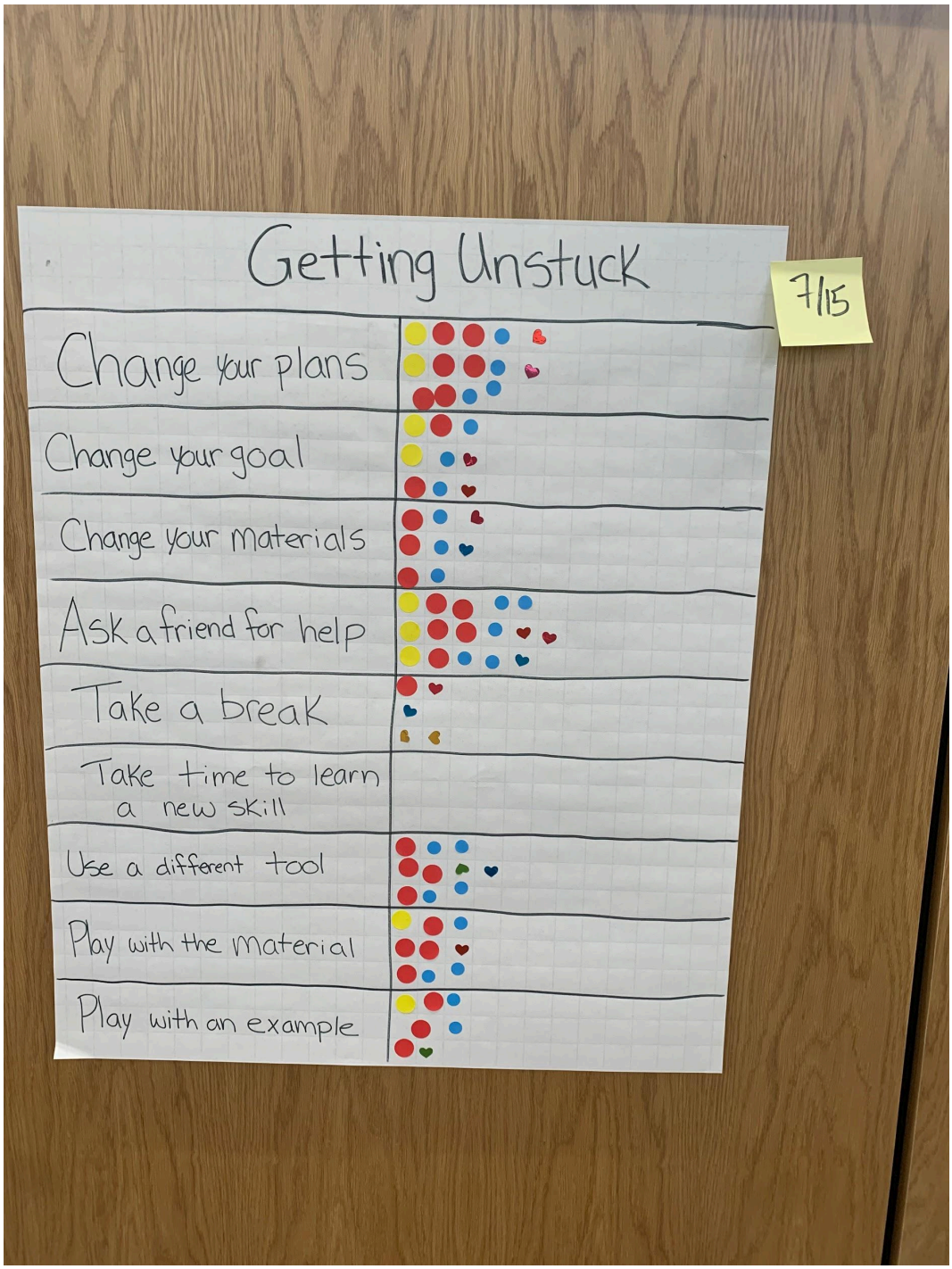
Educator	Child	Environment
A failure moment experienced by an educator in conflict resolution, facilitation, body language, tone, etc.	A failure moment experienced by a child in problem solving, understanding, tool use, observation, self-reflection, perseverance, etc.	A failure moment caused by room set up, materials or tools provided, space set for failure, etc.

Things that went well:	Possible Changes

Date:

Appendix 4:

'Getting Unstuck List' (Montshire Museum of Science)



The 'Getting Unstuck List' shared by Montshire asked youth to indicate what strategies helped them most.

Appendix 5: FiM Project Logic Model