Failure: Learning How to Problem Solve

Anita Mendis and Adam V. Maltese

Topics: Maker education, STEM, Failure, Prototyping

Summary
This research brief explores how failure is viewed by maker educators both in formal and informal programs, & how they respond to youth who 'fail' in the context of making activities. In doing so, shared practices among educators emerge that can be used as a list of strategies to improve learning and positive outcomes for youth when failure is encountered.

Background
The data for this project comes from researchers who observed moments of failure that occurred during making activities and educators' and youth's responses to them. As part of this work, the researchers used surveys with open-ended questions such as "In what ways do you see failure happening in your maker programming?" and "What is your typical response to a student when s/he states, 'I need help'?" Researchers found that participant responses could be categorized into four groups: ask youth questions, suggest youth seek advice from peers, suggest youth do research, and troubleshoot together.

Research Design
For this study, 107 maker educators (81% caucasian, 4% black, 4% asian, 3% hispanic) participated from across 32 states. These individuals reported offering making-related programs such as makerspace, STEM, STEAM, or other engineering or tinkering clubs for an average of 5.5 years. The researchers estimated that two-thirds of the participants were informal educators, while one third were formal educators. Sixty-two percent of the educators were female. Participants were solicited from different networks where maker educators communicate, such as The Connectory.org and MakerEd.org.

Finding 1
Maker educators view failure in two general ways. When asked *What two terms or phrases come to mind when you hear the word failure?*, educators described failure first as a learning opportunity, and then as part of the design and iteration process. Failure was most commonly reported during prototyping (26%) as well as when youth simply lacked the skills, knowledge, materials, or time to proceed (10%). Having to showcase their products publicly also triggered dramatic responses to failure in youth.

Maker educator responses when asked how frequently youth in their programs actively participated in or demonstrated 21st Century skills.

Table 1
21st-Century Skills (% of responses).

Prompt	Never	1–2 Times	Weekly	Multiple Times/Week
Be open and responsive to new and diverse perspectives; incorporate group input and feedback into the work	8	27	49	16
Engage in argument from evidence	20	40	28	12
Articulate thoughts and ideas effectively using oral, written, and nonverbal communication skills in a variety of forms and contexts	7	27	41	25
Plan and carry out investigations	10	29	44	18
Utilize time and manage workload efficiently	8	23	39	30
Assume shared responsibility for collaborative work and value the individual contributions made by each team member	6	27	42	26
Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems	10	38	32	20
Define their own problems to investigate	11	40	34	16
Go beyond basic mastery of skills to explore and expand one's own learning and opportunities to gain expertise	5	36	30	30
Develop and use models	17	29	35	19
Monitor, define, prioritize and complete tasks without direct oversight	12	21	40	27
Develop, implement, and communicate new ideas to others effectively	8	20	47	26
Analyze and interpret data related to their project	18	42	26	14
Work effectively in a climate of ambiguity and changing priorities	10	31	25	34
Solve different kinds of non-familiar problems in both conventional and innovative ways	1	31	41	27
Design solutions to a specific problem or task	2	25	45	28
Incorporate feedback effectively	11	17	50	23
Elaborate, refine, analyze, and evaluate their own ideas in order to improve and maximize creative efforts	6	22	37	35
View failure as an opportunity to learn; understand that creativity	1	24	40	35
Use mathematics and computational thinking	9	24	38	28
Adapt to varied roles, jobs responsibilities, schedules, and contexts	9	36	39	16
Deal positively with praise, setbacks, and criticism	0	17	48	35

Note. Prompts from Partnership for 21st Century Learning (2015). Percentage based on total number responded per prompt.

Finding 2

When youth experience failure in some way (get stuck, say ‘I need help’, etc.), most educators indicated that they ask probing questions to gain insight into the nature of the problem so as to better ‘troubleshoot’ with youth, or celebrated the failure as a learning opportunity and have the youth try again, thereby reinforcing persistence. These courses of action increase collaboration and self-confidence among youth, and lesson dependence on facilitators.

So what?

Failure is essential to learning, especially learning how to problem solve. If youth are expected to tinker and learn from failure, then they need tools or strategies for troubleshooting when they get stuck. Educators can and should intentionally plan for failure and explicitly teach strategies that equip students to become independent thinkers. Strategies educators can use while making with youth:

- Set up classroom norms for failure within the iteration process
    - Explain how iteration is an integral part of making and that innovation is a cyclical process.
    - Have youth use engineering/STEM journals to document the evolution of prototypes to products.

- Make and display a list of troubleshooting strategies before making or other learning activities begin:
    - Seek help from peers (e.g. “Ask three before me”).
    - Seek help from outside resources, such as the internet.
- Model troubleshooting techniques
    - As a facilitator, be willing to fail in front of kids and learn with them.
    - Share anecdotes of past problems and how they have been resolved.
- Minimize constraints as much as possible
    - Include time for multiple prototypes within product deadlines.
    - Give youth choice when it comes to tasks and public performances or presentations.
- Resist the urge to step in and directly fix the problem
    - Ask questions to guide youth to find their own solutions.
    - Use documented designs (in student engineering/STEM journals) as discussion points or for clarification.
    - Balance exploration time and structured time as much as possible.

Source:

Maltese, A. V., Simpson, A., & Anderson, A. (2018). Failing to learn: The impact of failures during making activities. *Thinking Skills and Creativity, 30*, 116-124. doi: https://doi.org/10.1016/j.tsc.2018.01.003