So what/moving forward
Use in the design of learning in informal, emergent makerspaces – taking an artistic (as opposed to a scientific) framework for learning

WHAT IS THE MAKER MOVEMENT?
If you want something you’ve never had, then you’ve got to do something you’ve never done.

This is the Maker Manifesto

1. We will wait for no one.
2. We will make the things Africa needs.
3. We will see challenges as opportunities to invent, and invention as a means to proving African ingenuity.
4. We will be obsessed with improving things, whether just a little or a lot.
5. We will show the world how sexy African manufacturing can be.
6. We will hunt down new skills, unmask locally made materials, keep our work sustainable and be kind to the environments in which we make.
7. We will share what we make, and help each other make what we share.
8. We will be responsible for acting on our own ideas.
9. We will forge collaborations across our continent.
10. We will remake Africa with our own hands.

Maker Faire Africa
“I am calling on people across the country to join us in sparking creativity and encouraging invention in their communities.”

President Obama
Maker Movement in Education

Art + Engineering + Entrepreneurship

*Making* as activity

*Makers* as identities of participation

*Makerspaces* as communities of practice


Studio Habits of Mind as Dispositions

Thinking Dispositions, Harvard Project Zero, Perkins, Tishman & Jay
Thousands of small, but thoughtful, interactions responding to and guiding students while they work
Careful analysis of “enacted practice” – how interactions support studio thinking

- Analysis of “Students at Work” time
- Coding of 4179 “Interaction units” between teacher and student(s)
- Blind inter-rater reliability in coding: Cohen’s Kappa (.70-.95)

<table>
<thead>
<tr>
<th>Interaction Units 49</th>
<th>Sum</th>
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<th>Fraction</th>
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<tr>
<td>Studio Practice</td>
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<td>Engage and Persist</td>
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<td>Observe</td>
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<td>&lt;1/10</td>
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<td>20%</td>
<td>1/5</td>
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<tr>
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<td>29%</td>
<td>2/7</td>
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<tr>
<td>Observe</td>
<td>14</td>
<td>29%</td>
<td>2/7</td>
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<tr>
<td>Question &amp; Explain</td>
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<td>35%</td>
<td>1/3</td>
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<tr>
<td>Evaluate</td>
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<td>37%</td>
<td>3/8</td>
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<tr>
<td>Technique</td>
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<tr>
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<td>26</td>
<td>53%</td>
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</table>
Understand Art World
Develop Craft
Stretch & Explore
Engage & Persist
Reflect
Envision
Observe
Express
Some features of the studio learning environment

**Individualized instruction is pervasive**
The bulk of students’ time is spent working with teachers observing and having informal one-on-one consultations on students’ progress. On average, during the roughly 2/3 of class time devoted to “Students at Work” there was an average of 154 teacher interactions with individual students while they were working.

**Reflection-in-Action central to studio work.**
36% of interactions asked students to reflect on their work either through evaluating or explaining some aspect of the work or their thought process about the work.

**Craft emphasized in connection with other “habits of mind”**
About 28% of the interactions between students and teachers involved some aspect of developing technical craft, but this was almost never in isolation—typically one or more other habits of mind were wedded to any discussion of technique.
Maker Movement in Education

Art + Engineering + Entrepreneurship

*Making* as activity

*Makers* as identities of participation

*Makerspaces* as communities of practice


Phase 1: A comparative case study approach to understand how and what people learn from their participation in makerspaces
Research Question

How do makerspaces function as learning environments?

a) who participates in the makerspace, how their participation changes over time, and what they learn through participation

b) how tools, materials, and processes are used, in what ways, and to what ends

c) how learning/teaching/collaborations are arranged at the sites.
When I started Sector, I was mainly thinking it was about equipment and tools...I quickly realized it was about the people. About bringing people together to make things.

Founder, Chris
• Sector67 is a Community Workspace / Hackerspace / Makerspace / Collaborative Environment in Madison, WI dedicated to providing members the opportunity to work on tomorrow’s technology; to build, collaborate, learn, and teach about next generation devices.


Sector67 website overview:
http://www.sector67.org/blog/about/
About 800 sq meter workshop

Sector67 Floor Plan
I mean I always talk about the community here being the biggest thing. You know there's quite a few very sharp people and people that have a lot of experience...this being a hackerspace you get a lot of alternative experiences rather than just traditional education...you don't usually get the normal way of doing things, which is kind of a good thing. Because you tend to learn a lot from that.

Monthly open meeting where members pose ideas, describe projects, invite collaborators, wrestle with problems.

*Sector67 member founding a start-up company in the space*
Multi-year collaborative projects
Connected to traditions and community

Annual community ‘iron pour’
Mt. Elliott Makerspace: Detroit, MI

“a village workshop where people make, tinker, and learn together.”

Workshop located in the basement of the Messiah Church

I’ve changed a lot. I’ve gotten more knowledge. I’ve gotten better. I’m more useful now. I can do more stuff. I can help more people...I have more opportunities. I’m useful.

11 year old Mt. Elliott member

All photos courtesy of Mt. Elliott Makerspace
Now I kind of think about everything...like ‘what makes it tick?’

I knew nothing about circuits or the flow of electricity or anything like that...I like plugged stuff in all the time and I don’t –didn’t- really think like ‘what makes this work?’, like how the electricity goes into it, how it works... Like if I’m not interested, I don’t think twice. I wasn’t thinking about it ‘til I got to the makerspace. Now I kind of think about everything—like what makes it tick.

Mt. Elliott member for 4 years since she was 17
“I’m more on the lookout… like maybe I can use something I’ve got already.”
RESOURCEFULNESS:
individual or communal acts of innovatively drawing on internal sources (e.g., skills, knowledge, confidence) and external sources (e.g., experts, informational texts, community partners) in order to persist in meeting individual or communal needs and wants.
(Sheridan & Konopasky, 2016, p 31)

ASSET-MAPPING:
Identifying the resources available to you as an individual (e.g. your skills, knowledge, dispositions, tools) and a community (e.g. local expertise, social connections, shared tools and materials)

contrasts with ‘deficit thinking’ where a focus is on what students don’t know, what a community doesn’t have
Children’s Museum of Pittsburgh

https://pittsburghkids.org/
Welcome to MAKESHOP

This is a place to mess around with materials and tools, play with ideas and make things together.

We invite makers of all ages to explore MAKESHOP for your safety, some experiences will be limited in capacity and age level. No matter your age, we believe you are a maker.

https://pittsburghkids.org/exhibits/makeshop
Makeshop Artist Educators

- Children’s “ways in” to making
  Products
  Processes
  Materials
Cross-material/technology connections
Evocative objects give ideas
Material design for very young children

When preschoolers program with building blocks matched to object-oriented computer programming elements, they see the results of their choices on a screen.

Bolts and screws sized even for toddler fine motor skills hold panels together in their own life-size fort designs.
Designed to support family connections

Photo credit: Anthony Musmanno c/o Children's Museum of Pittsburgh
Learning through Making: Making with circuits in three makerspaces
Students will be able to:
• apply the terms insulators, conductors, open and closed in describing electrical circuits.
• differentiate between an open and closed electric circuit.
• use the dry cell symbols (ñ) and (+)

• create and diagram a functioning series circuit using dry cells, wires, switches, bulbs, and bulb holders.

School-Based “Hands on” approaches and goals

Students will be able to:
• apply the terms insulators, conductors, open and closed in describing electrical circuits.
• differentiate between an open and closed electric circuit.
• use the dry cell symbols (ñ) and (+)

• create and diagram a functioning series circuit using dry cells, wires, switches, bulbs, and bulb holders.
Commercial “Kit” based approaches
"We have this stuff at home...we could make these."  mother to preschool child
“Wrecklabs” and “BreakMake”: Reverse Engineering to Designing

“there is nothing more satisfying that ripping apart old electronics to see what is inside. Printers, Scanners, old computers, DVD players, clock radios… nothing was safe from the destruction! The best part is reusing the parts inside to make new and amazing stuff!” [adult organizer of “Wrecklabs” and “BreakMake”]
Studying how one learner takes an idea from the breaking through the making design process.
“Natural Test” of Resourcefulness of Community:
Repair/rebuild/transform a broken electric wheelchair
“now my mom wants me to learn to fix cell phones...she tells me she’s gonna give me tests like she’s gonna drop it...gonna throw it in water...just to see can you tell what’s wrong with this?...Are you able to fix this?”

12 year old Mt. Elliot Member
Apollo 67
Sector 67 Balloon launches

“Once again, the lesson (which we clearly did not learn after the first attempt), was to take things slowly and methodically, and only launch under the best conditions.”
– Apollo67 Blog 11/28/11 (Launch 2)
“The purpose of the cold test was to determine if the foam would be sufficient to protect the phone at temperatures at altitude and if the phone would continue to operate the duration of the flight.”

Apollo67 Meeting Minutes 11/01/2011 (Launch 1)

“The experiment for this weekend used a ChipKit (an Arduino clone built on the Microchip line of microcontrollers) and an APRS module, which is short for Automatic Packet Reporting System.” – Apollo67 Blog 12/16/2012 (Launch 3)
The short and the long of learning in the making

“experiencing making”
Makeshop: Micro-view of a participant trajectory (how does participation change, develop over the course of one visit in Makeshop)

“becoming a maker”
Mt. Elliot Makerspace: Middle-range participant trajectories at the activity, individual, or group level. (e.g., looking at the evolution of a 3 week long project; tracing individual’s 2-3 years of changing involvement)

“sustaining a maker practice”
Sector67: Making as a part of adult life, making activities embedded in individual’s long-term interrelated bodies of work, making activities that help sustain a group identity (e.g., mini-cars, balloon launches)
Multi-disciplinarity

“Now I kind of think about everything—like what makes it tick.”  Mt. Elliott Makerspace Member
Marked diversity of learning arrangements
Learning is in and for the making
Phase 2: Sample Design Experiment

Research Problem

If you have novice learners for a short time (e.g., one 45 minute session at a museum), how should you structure the learning experience?

Comparison of “step-by-step”/kit approach and a more open-ended “Makeshop” approach
Phase 2: Sample design Experiment

- 36 4th grade students on a field trip to Children’s Museum randomly assigned to two groups for a 45 minute session of making with circuits.

**Group 1: “Kit” approach** - Structured making activity involving circuits (making a “brushbot”). Students are each given a kit materials and step-by-step instructions. Teacher shows components of a simple working circuit using the elements they each have and leads them through how to make their own brushbot.

**Group 2: “Makeshop” approach** – Components of simple circuits are available for children to explore as teacher demonstrates simple circuit. They are encouraged to test them out and given an open-ended design challenge to make something with them. Bins of recycled materials and conductive and non-conductive tools for fastening (e.g., glue guns, electric tape, staples, tape) are openly available in the area.
Circuit Knowledge

- No difference between groups in circuit knowledge pre/post test

- No difference between groups in ability to make a working circuit during session
Interest, Usefulness, Self-efficacy

(Adapted from SALES Inventory; Chronbach’s Alpha = .87-.9)

Usefulness of experience

(sample items: What I learned is useful for me to know; what I learned is of practical value)

Youth in the open-ended Makeshop condition rated their learning from making as more useful (M=4.25, SD=1.18) than youth in the “Kit” condition (M=3.21, SD=1.36); T(34)=2.22; p=.03. There were no significant differences between the groups in terms of ratings of interest or self-efficacy.

Qualitative data:

In their written statement telling about their project, youth in the Makeshop condition were more likely to include an aspect of their creation’s function or purpose in their description; T(33)=3.76; p<.001.
• Sample Makeshop artists’ statements

“The Blue Wake up Mobile. So if you’re a teacher the children that don’t pay attention or fall asleep put it by them they wake up!”

“I made relaxer to make something relax. I made a relaxer for people who work all done.”

“I made a fan. It's a colorful one and it's to cool down people and stuff [sic].”

Sample “Kit” Group artists’ statements

“I made a brush bot. I made the brush bot because it seems [sic] fun and it is something anybody can make.”

“A brushbot because we are learning about switches.”
Kit example:

“I don't know why I made it. And it doesn't work.”

Makeshop example:

“I have 2 AA batteries [sic]. My problem [sic] was the sticky part of the tape on the red wires didn't let you make electricity.”
Envisioning next idea

Youth in the Makeshop group were more likely than the “kit” group to write down and/or draw an idea of what they would like to make next.

Sample ideas: “A windmeel [sic] in a farm.” “I would make something like a water play you turn on the switch and water comes out.” “The Flying Car Airplane”

Sample lack of ideas: “I love it all.” “I don’t know.” “I want to make something else than this because it doesn’t work.”

Konopasky & Sheridan, 2015, AERA
Emerging functional linguistic model: Youth in Makeshop condition showed more markers of agentive speech

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<th>Red Group</th>
<th>t-test</th>
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<td>5.17 (2.92)</td>
<td>7</td>
</tr>
<tr>
<td>First-person plural (we)</td>
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<td>7.5 (5.79)</td>
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<table>
<thead>
<tr>
<th>First-Person Process Type Mean Differences</th>
<th>Classroom Group</th>
<th>Makeshop Group</th>
<th>t-test</th>
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<tr>
<td>Process Type</td>
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<td>M (SD)</td>
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<td>9.67 (4.27)</td>
<td>7</td>
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<tr>
<td>Mental (e.g., I think)</td>
<td>6</td>
<td>1.83 (2.23)</td>
<td>7</td>
</tr>
<tr>
<td>Relational (e.g., I am)</td>
<td>6</td>
<td>.67 (.52)</td>
<td>7</td>
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‘Kit’ based experience

small excerpt of talk about project:

Tangerine: Like we broke the toothbrush. It was hard to clip it so we had to twist it around. And when, like, it is falling and all that and we had to put it on there and we had to tape it. But the battery was so, like- We- it was negative and positive. Like one was bumpy and one was smooth, really. And the motor, sometimes, we had to tape it on there but it falls off.
Open-ended design experience

small excerpt of talk:
Apple: Oh. So I-I decided to do like open the roof. I taped it-, I taped it together. I-I learned that I can take- that I can take the battery out. So I-I cut this a little more so I could easily- easily get this out of here. We used these recycled materials. And then I put the battery in. See, this is the plus which means the positive goes on this side.

Interviewer: Yeah

Apple: So then I looked close and I put the thing...
What might we care about in studying learning in making?

- Content/material specific (e.g., circuit knowledge, welding skills, technical knowledge)
- Design process skills (rapid prototyping, iteration, brainstorming)
- Sense of agency or autonomy
- Resourcefulness (individual and communal)
- Creativity (Problem finding, problem solving)
- Studio Habits of Mind
- Community outcomes—asset mapping, collective creativity, collective self-efficacy
- Entrepreneurship (product development, start-up companies)
Learning that is in and for the making
Theoretical constructs

Thinking through designing and making external representations:
  Constructionism (e.g., Harel, 1991; Kafai, 2006; Kafai & Resnick, 1996; Harel & Papert, 1991; Peppler & Kafai, 2007)
  Design-based learning (e.g., Ching & Kafai, 2008; de Vries, 2006; Gray et al. 2001; Hmelo, Holton & Kolodner, 2000; Kolodner et al., 2003; 2004)

Communities of practice /atelier learning environments:
  e.g., Brown, 2006; Lave & Wenger, 1991; Wenger, 1998;

Interest-driven, self-initiated, self-directed learning:
  e.g., Barron, 2006; Brice-Heath, 2005; Crowley & Jacobs, 2002; Hidi & Renniger, 2006; 2015; Ito et al. 2010

“Participatory cultures” and digital creative production
  e.g., Halverson, 2012; Ito et al., 2010; Jenkins et al., 2007; Peppler, 2010; Peppler & Kafai, 2008; Sefton-Green & Sinker, 2000; Sawyer, 2012; 2016

Design-based research methods:
  e.g., Barab & Squire, 2004; Brown, 1992; Cobb et al. 2003; Collins, Joseph & Bielacycz, 2004; Design-Based Research Collective, 2003; Kelly, 2003; Sandoval & Bell, 2004
Related works:


Also:
