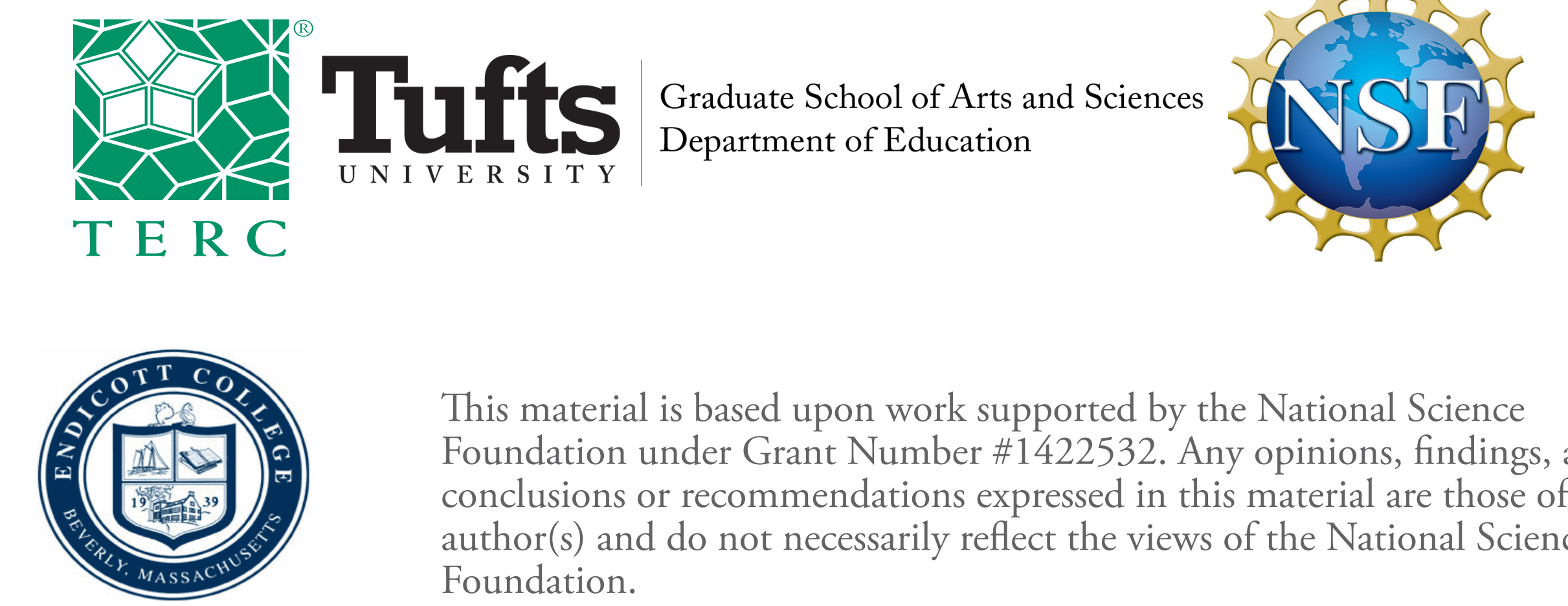## The Team

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STEMLiMS
Investigating STEM Literacies in MakerSpaces

What STEM literacy practices are used in makerspaces? How can they inform the design of makerspace pedagogies for youth?

Overview and Goals

Makerspaces are social spaces with tools, where individuals and groups conceptualize, design, and make things using new and old technologies.

Literacy practices are the ways people use representational texts to navigate and make sense of their worlds. They are used in particular contexts with particular goals. By "representational texts" we mean written words, talk, photographs, diagrams, videos, schematics, computer code, electrical circuit diagrams, mathematical notations, gesture, and myriad other representations. In this project we aim to,

• Describe the ways in which people use representations to engage in science, technology, engineering, and mathematics (STEM) while making.

• Create bridges between informal spaces - where the bulk of makerspace activities currently reside - and formal spaces - like schools.

• Broaden what it means to participate in STEM disciplines in schools by recognizing the ways in which **makerspaces promote pexpansive and creative STEM practices.**

• **Engage new youth in making** by building from the literacy practices that *all* youth bring to creative and personally meaningful activity.

• **Design literacy supports for new makers** to engage in makerspace activities and develop literacy practices that are useful across all STEM disciplines, in both formal and informal settings.

Methodology

14 semi-structured fromal interviews with experienced makers across fields to identify possible literacies for observation; 2 Sites: Artisan's Asylum (AA) and DGF Technologies (DGF); 200+ hours of participant-observation across design, fabrication, tinkering, and public-sharing oriented activities including management and teaching activities. Data sources included: fieldotes, audio, video, photographs, documents. Semi-structured formal interviews: 19 at AA; 7 at DGF

STEM Literacy Practices in Interviews
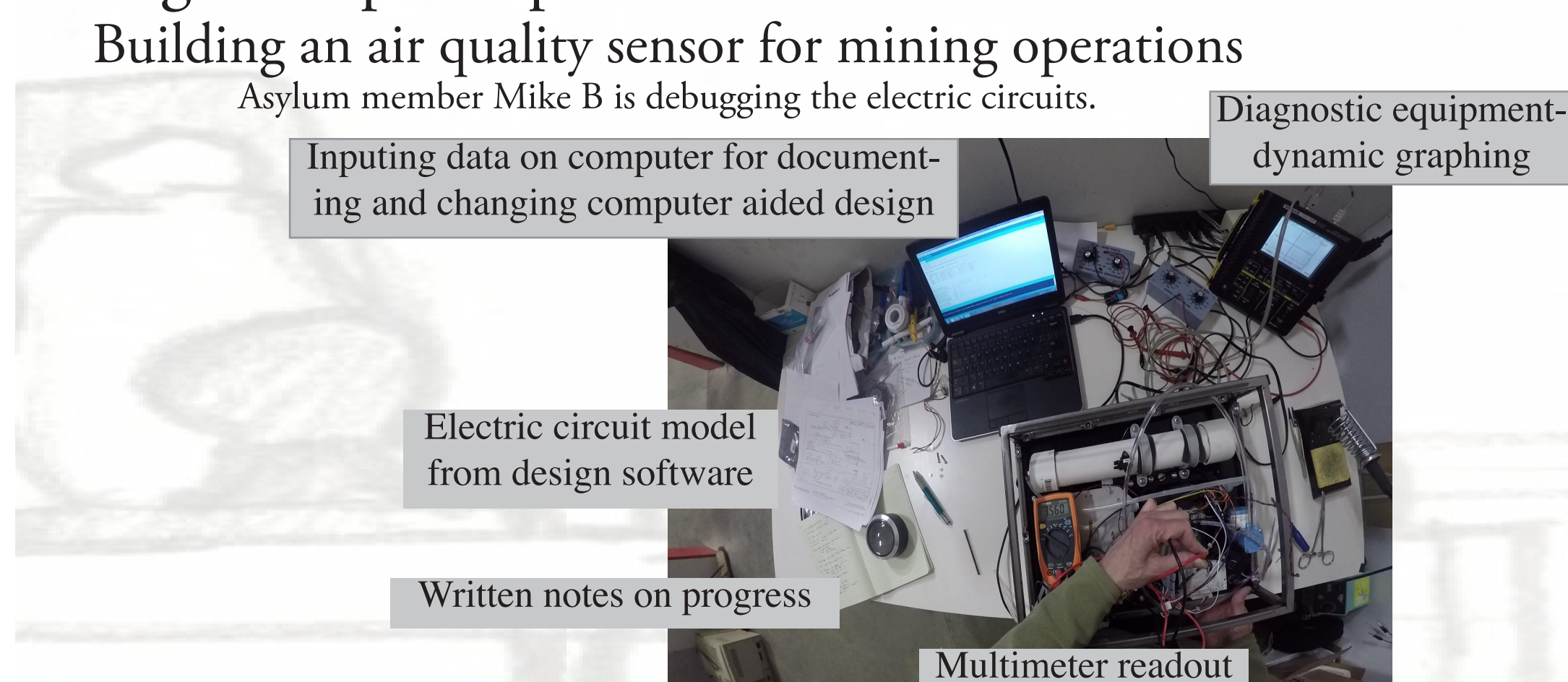### Initial round of coding: Percentage of literacies in codes

Literacy Practice	Definition/Example	Experts	AA	DGF	Total
Posing and solving problems in the world and in the design process	Identifying emergent and/or unanticipated problems, collaborative discussions around moment-to-moment adjustments in the process of fabrication.	12%	18%	6%	13%
Interpreting, creating, and traversing representational forms	Making meaning with and across multimodal representations (e.g., talk, sketches, diagrams, notes, 3D models). Symbolic representations as aids in making.	37%	27%	34%	34%
Identifying, organizing, and integrating information across sources	Use of reference guides, spec sheets, and product manuals. Also, searching for information on the Web, watching online how-to videos.	22%	6%	6%	15%
Communicating ideas and information in new ways to different audiences.	Demonstrations of made artifacts, web pages or social media, providing or seeking help; or feedback. Raising or earning money.	25%	46%	50%	34%
Documenting process and/or milestones	Photographing, writing about, or otherwise recording the steps, stages, processes, and output of a project for oneself or as a reference for others.	4%	3%	4%	4%

Year One Case Studies
Artisan's Asylum (member-run makerspace)

5 years old, 40,000 Square Feet, 350 Members, 3 Staff, Shops: woodshop, electronics, welding, CAD, digital fabrication, CNC, casting, machining, screenprinting, hot crafts (jewelry)

Using Multiple Representations to Solve Problems
Building an air quality sensor for mining operations

Asylum member Mike B is debugging the electric circuits.

Inputing data on computer for documenting and changing computer aided design

Diagnostic equipment-dynamic graphing

Electric circuit model from design software

Written notes on progress

Multimeter readout

"In this kind of environment, you can work a lot more quickly. So, the representations are often not solidified in the ways a more traditional engineering system might work. If it ever gets to a point where this thing needs to be made in the thousands, or tens of thousands, then it needs to be tightened up. In this kind of environment, you can work much more quickly. The thing you make is the most important thing, the representations are an aid, but they don't become so solidified that they slow the process down."

- Richard

Space Mediates Communication
"You're invited and expected to interrupt, bother, and collaborate." - Ecco, Sculptor/Visual Artist/Teacher

"In the beginning I wasn't talking that much because I was trying not to bother people. But then I started to know more people and now I always ask things if I don't know – technical things about the wood shop and the machines. And also about how to make the packaging. If you talk about your problem, they will think about your problem because it's something they like to do. It's like a game." - Camila, woodworker/interior designer

"The thing about this place, if you take a walk down the hall usually the idea you need comes to you, or the tool, or the material. But you have to be here not just walking around outside." - Chris K.

DGF Technologies
(small business for rapid prototyping)

1.5 years old, 9 employees, 3D CNC machines, digital fabrication, services from design to production to marketing

Learning and Stratification in Literacy Practices

Employees were given time to learn tools on their own, and for consequential projects. For instance, an initial training was for shop workers to design and create laser cut boxes for 3D printer film. In other instances, when employees had a question, they were told to "find it out on your own" as a way to give ownership over learning process.

The whiteboard provided an interactive space for design team members to draw and discuss their designs, easily able to depict alterations or alternative designs with the eraser and markers.

Management and the creative team were involved in all stages of product development and accounted for almost all of the literacy practices related to creation of representations.

Shop Manager created and controls the visual representation of the work. Shopfloor workers look on.

Shop floor team rarely created representations and sometimes did not see any at all in the process of fabrication.
"There weren't any representations used, not for me personally. I didn't design them in CAD; someone else did. So I actually didn't visually see anything like that." -Natalia, shop floor worker

Traversals and Translations in Representations

"It's getting to the core of their idea, detailing the features they want, then inserting a break point where internally, we meet after that, so I've captured all the info. Have all that stuff documented, I present it to the team, making myself a client representative so I kind of argue for them at that point."
- Erik Client, relations representative

WELDING SYMBOLS
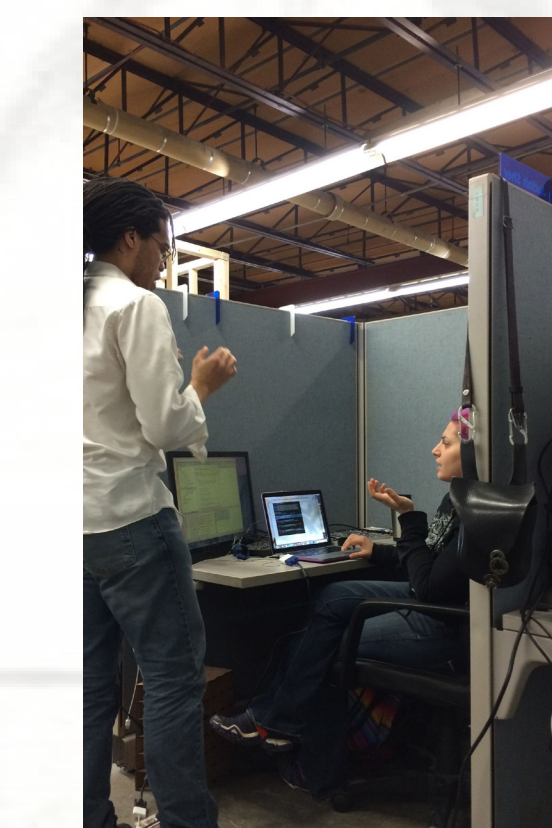
"We use [sketches and models] while we're talking about them. In the early stages, it will be sketches kind of, and you know, that doesn't involve me, but when they're pulling the information out of the client as far as what they want, which can be difficult, they'll use sketches and then we'll turn that into, well, actually, sometimes before we even do the work, we'll turn that into just like rough kind of digital representations to make our understanding of the project clear for the client, so they don't misunderstand our understanding of the project."-Pete, shop manager

Discussion

Interviews
• Communicative literacies more prevalent in social spaces.
• Individually looking for information more prevalent among initial interviewees.
• Likely this is related to the reasons why people join or stay at makerspaces, they like talking to others.
• Documenting was low in interviews, but fieldnotes suggest almost everyone did some kind of documenting.

Case Studies
In both sites independent learning was valued in which people were encouraged to (safely) work on their developing skills.

At DGF, representations, were mainly created as models for manufacturing. (e.g., a whole room to simulate an interactive museum exhibit, sketch of electrical wiring on a blank sheet of paper). At AA, literacy practices were used to to iterate ideas, and communicate with present and possible future clients, collaborators, or patrons.

Work in makerspaces uses representations that are not always solidified or formalized. "Sketch" culture, but in lots of forms. Schools rarely value the partially complete, first-draft types of representations that students are more than capable of producing.

Implications

• Provide clipboards with white paper and black pens.
• Cover work surfaces with paper for writing, scribbling, sketching.
• Big white boards--some with grids or lines to sketch formal diagrams.
• For electronics, magnets with symbols of major components that can be moved around simply to sketch out a circuit.
• For modeling, hunks of clay and "play-doh" at the stations where 3D design happens to mold out parts/shapes.
• Encourage developing and drawing on distributed expertise.
• Hold community events, such as critique/explanation sessions, often.
• Create opportunities for whole community collaboration.
• Support creation of multiple representations.
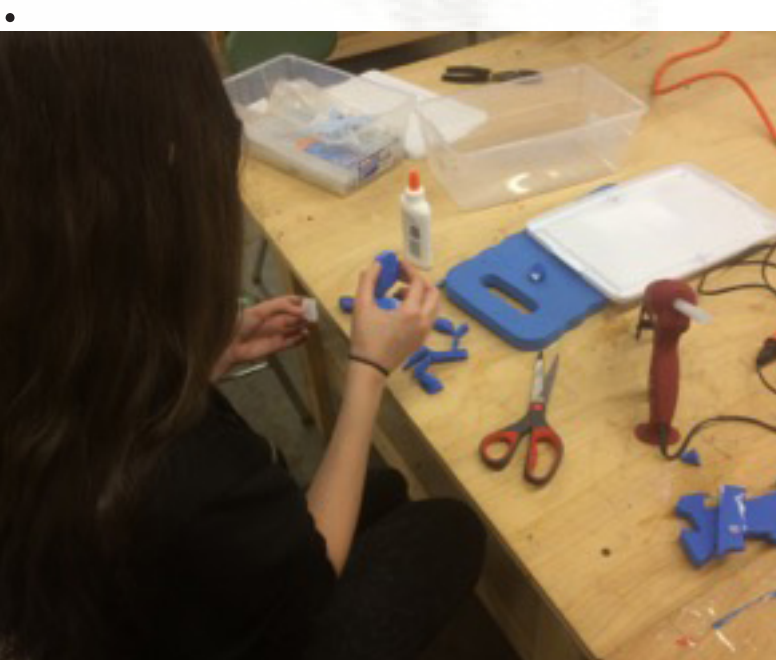
Next Steps

In addition to observing high school and elementary school youth in two informal makerspaces in Year 2 of the project, we will be trying out some small interventions.

For instance, we plan to try an image based photography tool for documentation. We also plan to create opportunities for collaborative projects that benefit the space, focusing on multiple representations and iterations of ideas.

3-Year Study: Ethnography Design Research

Year 1 - *Informal* Adult Makerspaces
ARTISAN'S ASYLUM / DGF TECHNOLOGIES
Observations and interviews with experienced makers to define and describe activities and literacy practices.

Year 2 - *Informal* Youth Makerspaces
SOUTH END TECHNOLOGY CENTER at TENT CITY / Boston Centers for Youth & Families
Observations and interviews with youth in informal makerspace settings to generate expansive definitions of practices.

Year 3 - Designing Literacy Supports for *Formal* & *Informal* Spaces
Cambridge Friends School CFS / @ Malden High School, Nedlam'sWorkshop, Somerville STEAM Academy
Develop and test literacy supports to help new youth makers engage in rich inquiry and expression in school-based makerspaces.

Dissemination

Gravel, B., Tucker-Raymond, E., Kohberger, K., & Browne, K. (2015, September). Literacy practices of experienced makers: Tools for understanding landscapes of possibilities. *Conference Proceedings of Fablearn 2015 Annual Conference, Palo Alto, CA.* Accessed online: https://external-wiki.terc.edu/display/STEMLiMS/Publications.

Tucker-Raymond, E., Gravel, B., Kohberger, K., & Browne, K. (Under Review). Source code and a screwdriver: STEM literacy practices in fabricating activities among experienced adult makers. *Journal of Adolescent and Adult Literacy.*

Tucker-Raymond, E., Gravel, B., Kohberger, K., & Browne, K. (Accepted). STEM literacy practices in adult makerspaces: Implications for learning. American Educational Research Association Annual Meeting. Washington DC April, 2016.

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