Making and Tinkering in Robotics (and 4-H)

Handout from the 2014 NAE4-HA Annual Conference

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Extension in several states has been piloting 4-H *Maker* clubs and camps and National 4-H has been discussing *Maker* 4-H projects. *Make:*® and tinkering (M & T) have tremendous potential to give Extension and 4-H an opportunity to "re-brand" some of what we already do well and authentically.

Maker Movement

> *Young Makers "creates a collaborative culture of creativity, innovation and experimentation…there are no winners and losers; the focus is on exhibition, not competition." From* http://makermedia.com/about-us/making-in-education/

The do-it-yourself (DIY) culture resurged in the 1970's with an assortment of practices – modifying objects by repurposing, reusing, and upcycling; fabricating scientific equipment to participate in citizen science, and self-publishing books. The *Maker Movement* is a technology-based extension of DIY emphasizing a spirit of innovation and creativity. Make is typically seen as the use of digital tools to design, create, and share projects. The *Maker Movement* has gained recognition as an approach to involve young people in technology-based projects (like programming an Arduino microcontroller).

The *Make:*® brand has been championed by Maker Media, Inc., which oversees the *Make Magazine*®, Maker Faire®, and Maker Shed store. The *Make Magazine*® is the pinnacle of the *Make:*® image. An analysis of cover arts indicates an emphasis on electronics; projects featured on the previous 36 covers in the past nine years have included 53% electronics, 31% vehicles, 22% robots, 8% rockets, and 5% music[i]. In addition, *Make:*® presents a narrow focus on who can be a *Maker*. Zero percent (0%) of covers of the past *Make Magazines*® have featured people of color and only 15% of covers have featured a girl or woman[i].

Tinkering

> **Tinkering: Indicators of Learning[ii]**
> - ✓ engagement: expressions of joy, frustration, curiosity
> - ✓ intentionality: self-direction, personalization, variation
> - ✓ innovation: repurposing ideas and tools,
> - ✓ solidarity: adapting ideas and tools

Tinkering is often found in science centers and designed settings as a hands-on open-ended activity where youth play and explore materials. Tinkering is often associated with play, as people try out ideas, make adjustments, and experiment with possibilities. This way of designing has been promoted as a way to improve interest in engineering and as a model for work in the disciplines. Tinkering is a powerful place to learn: "learning through tinkering is not serendipitous: it comes about through a process of design decisions and principles that create specific types of opportunities for learning"[ii].

Guided Making & Tinkering + Real-World Environmental Issues = Development of Creative Problem Solvers

Climate change, drought, food deserts, and energy issues will require innovative and creative solutions, so we need to prepare our young people to become creative problem solvers. The Make movement and tinkering have shown themselves to be powerful approaches to engage youth in open-ended thinking and problem solving. Now is the time to harness this to support youth in making authentic and positive change in their communities.

Research-base: Learning and Development through Making and Tinkering (M & T)

> *"Making could be a new and major chapter in this process of bringing powerful ideas, literacies, and expressive tools to children" - Blikstein, 2013.*

Making, together with tinkering, has been recognized as a practice that facilitates learning and development. In parallel, there has been a resurgence in engineering education as evidenced by its incorporation into the Next Generation Science Standards[iii]. While shop class, wood class, sewing, and other historical making was available in schools of years past, the push towards academic science, emphasis on abstract thinking, and budgetary constraints caused a decline in these opportunities in formal education in the second half of the 20th century[iv]. The *Maker Movement* and tinkering has the potential to raise support to re-encourage these types of opportunities in schools and the community.

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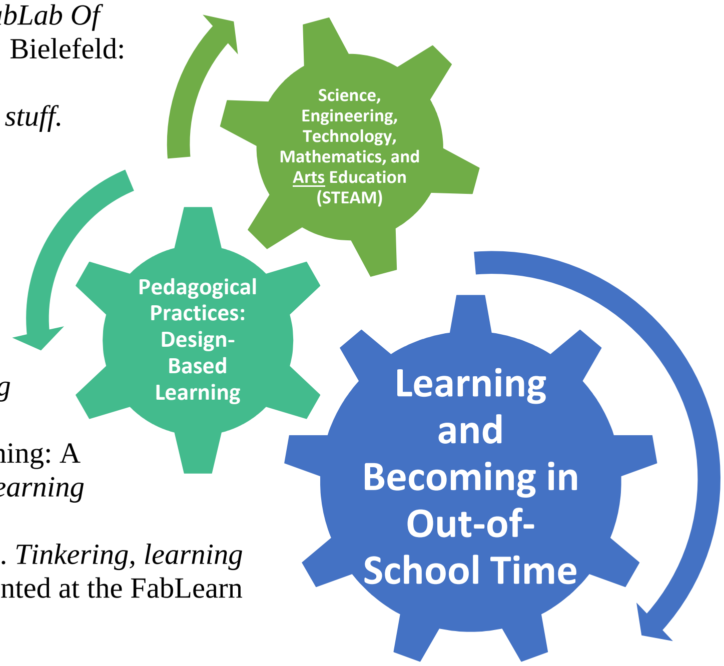

Pedagogical Practices of M & T: Design-Based Learning (DBL)

DBL is a special case of project-based learning, extends constructionism, and is a pedagogical approach that emphasizes planning, designing, and making shareable artifacts. DBL extends inquiry-based science learning with frequent opportunities for reflection and metacognition in the design process; enhanced motivation with application of learning to real world problems; promoting questioning through multiple iterations of design, testing, and failure; and creation of shareable artifacts serving as external representations of knowledge. DBL has been shown to foster problem solving abilities, creativity, and metacognitive skills.

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Opportunities for Making in 4-H

Making and tinkering are inherent to 4-H, both historically and culturally, and is deeply embedded in the hundreds of diverse projects in which 4-H youth participate each year. 4-H programs have engaged youth in making since its beginnings with a wide variety of projects: sewing, quilting, gardening, woodworking, and making of things from the land such as raising livestock and growing plants. The *Maker Movement* and tinkering, when leveraged for youth learning and development, share many similarities with 4-H. These include an emphasis on experiential and inquiry-based learning, which may be one reason branding 4-H programs as *Maker* is appealing. What 4-H, and the broader science education literature, may contribute to *Maker Education* is decades of research in youth development and design-based learning. We offer these considerations to Extension professionals adopting Making and Tinkering approaches:

- Strive to broaden the conception of making and who can be a *maker*. Celebrate the 4-H history of making, from cookies and quilts to robots and rockets. 4-H has an opportunity to celebrate the diversity of opportunities currently available in its programs, that 4-H is not “un-cool” or “old-fashioned” within the context of making.
- Extension programs striving to reach diverse and underrepresented audiences need to attend to culturally-relevant types of making and tinkering including art, clothing, foods, and language – and not just hi-tech.

Making & Tinkering in Robotics

Robotics can be a perfect context for implementing making and tinkering approaches. One example is the 4-H *Junk Drawer Robotics* curriculum which engages middle school youth in engineering design through design challenges with common household items. The curriculum embodies a “guided maker” approach to scaffolding youth participation in making and entrée to the broader make culture. This vignette illustrates the exploratory and “making” nature of repurposing objects in the JDR curriculum:

> *A facilitator challenges youth to build a pneumatic powered robotic arm using paint sticks, brass brads, rubber bands, wooden skewers, paper clips, along with plastic tubing and syringes for the pneumatics. The possible designs are limitless. The open-ended nature of the activity is seen by the repurposing of common household items. Small groups of youth collaborate to meet the design challenge often in vastly different ways. For example, if rubber bands are not available, how will youth work together to find an alternate?*

The open-ended approach promotes a materials engineering perspective, which promotes materials literacy, helping children become comfortable with exploring object affordances, reusability, and repurposeability.

Discussion Questions

- ☐ What will it take to promote making and tinkering in robotics within the context of Extension and 4-H?
- ☐ What are the essential pedagogical practices (teaching methods) educators’ should use to take a making and tinkering approach to educational robotics?
- ☐ How might making and tinkering approaches might be used with Robotics Platforms (like LEGO)?
- ☐ In what was does using a platform robotics kit constrain or afford making and tinkering?
- ☐ What might youth learn from participating in a making & tinkering oriented robotics program; and how would this differ from a more traditional educational robotics program?
- ☐ How might robotics help support youth in addressing real-world issues through making and tinkering?

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[iv] DeBoer, G. (1991). *A history of ideas in science education: Implications for practice*. New York, NY: Teachers College Press.