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STEM LEARNING AND RESEARCH CENTER

STELAR Webinar Series

Webinar 3 - Research & Evaluation

Tuesday, April 30, 1-2 pm ET

This material is based upon work supported by the National Science Foundation under Grant No. DRL 1614697. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

EDC Education Development Center

About STELAR:

- STELAR: STEM Learning & Research Center (STELAR)
- Resource Center for the NSF ITEST Program
- Located within Education Development Center in Waltham, MA
- EDC has supported the ITEST program since 2003

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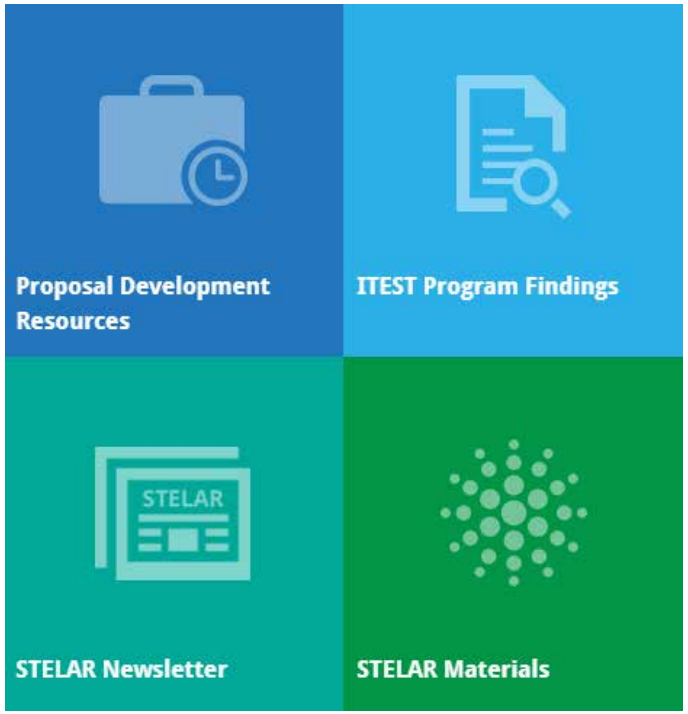
What STELAR does:



- **Technical support** the ITEST community
- **Disseminate** ITEST project findings nationally
- **Broadening participation** in the ITEST portfolio
- **Assisting** those interested in submitting an ITEST proposal

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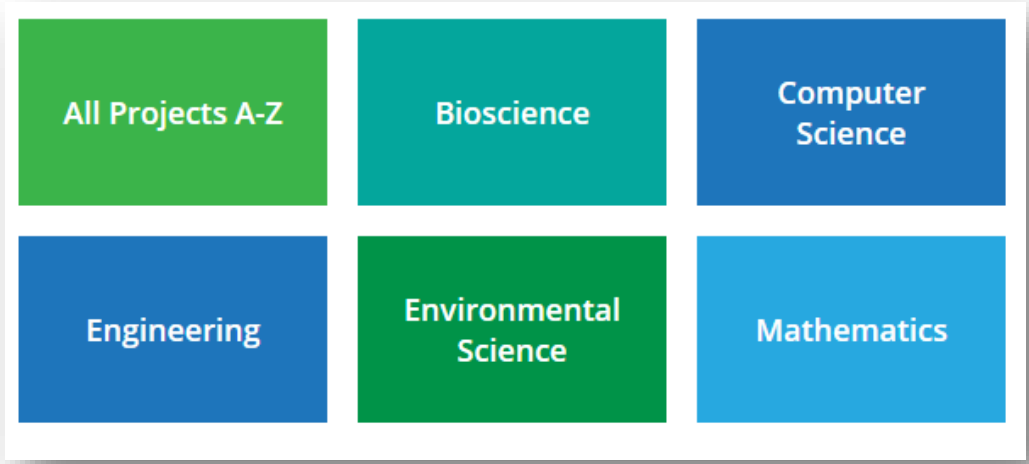
Resources:

Developing a Proposal

- + GET TO KNOW ITEST
- + PREPARE YOUR PROPOSAL FOR SUBMISSION
- + DEVELOP A ROBUST RESEARCH DESIGN
- + CREATE AN EFFECTIVE EVALUATION STRATEGY
- + CONNECT WITH PARTNERS
- + REACH UNDERSERVED POPULATIONS
- + DEVELOP THE WORKFORCE OF THE FUTURE

Project Profiles



Resource Library

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NSF's ITEST Program

- Innovative Technology Experiences for Students and Teachers (ITEST) Program
- Supports the research and development of innovative models for engaging PreK-12 students in STEM learning
- Builds students interest in and capacity to participate in the STEM and information and communications technology (ICT) workforce of the future
- Current solicitation is under revision
  Full Proposal Deadline Date: August 14, 2019

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Event Overview

Charting the Future of Making in STEM Education

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NSF EAGER Maker Projects

NSF 15-086

Dear Colleague Letter: Enabling the Future of Making to Catalyze New Approaches in STEM Learning and Innovation

June 4, 2015

Dear Colleagues:

The National Science Foundation (NSF) has contributed substantially to the development of the US *Maker Movement* and the exploration of *Making* as a pathway to innovations and learning in science, technology, engineering and mathematics (STEM). NSF's strategic fundamental research investments enabled many of the innovations underlying 3-D printing, computer-aided design, geometric modeling and computer-integrated systems. NSF has made a series of investments in the systematic discovery of new knowledge about learning through *Making* in diverse formal and informal settings including fab lab classrooms, television and interactive web media, undergraduate engineering, and the first-ever World Maker Faire.

Today, a growing number of people engage in STEM practices and learning through various forms of *Making*. The *Maker* approach encourages people to understand how things work, to experiment, invent and redesign things through multiple iterations, to democratize and understand processes of engineering, science, and innovation, and to commercialize new products by developing and testing prototypes quickly and in a cost-effective manner. *Making* frequently takes place in social contexts, often called *Maker spaces*, where collaborators, mentors, advisors, and others can be found. These emerging ideas are pointing the way to how the STEM research and education community can both benefit from and contribute to the *Maker Movement*, improving U.S. innovation and STEM workforce development.

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EAGER Maker Summit Goals

- Capturing current issues in the Maker movement with respect to education
- Identifying important research issues and trends
- Discussing NSF's investments in the Maker movement
- Recommending future directions for NSF research and development

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Summit working groups

- Broadening Participation
- Partnerships
- Process and Pedagogy
- Research and Evaluation
- Workforce Development

Discussion topics:

- Innovations
- Impacts
- Challenges
- Future of Making

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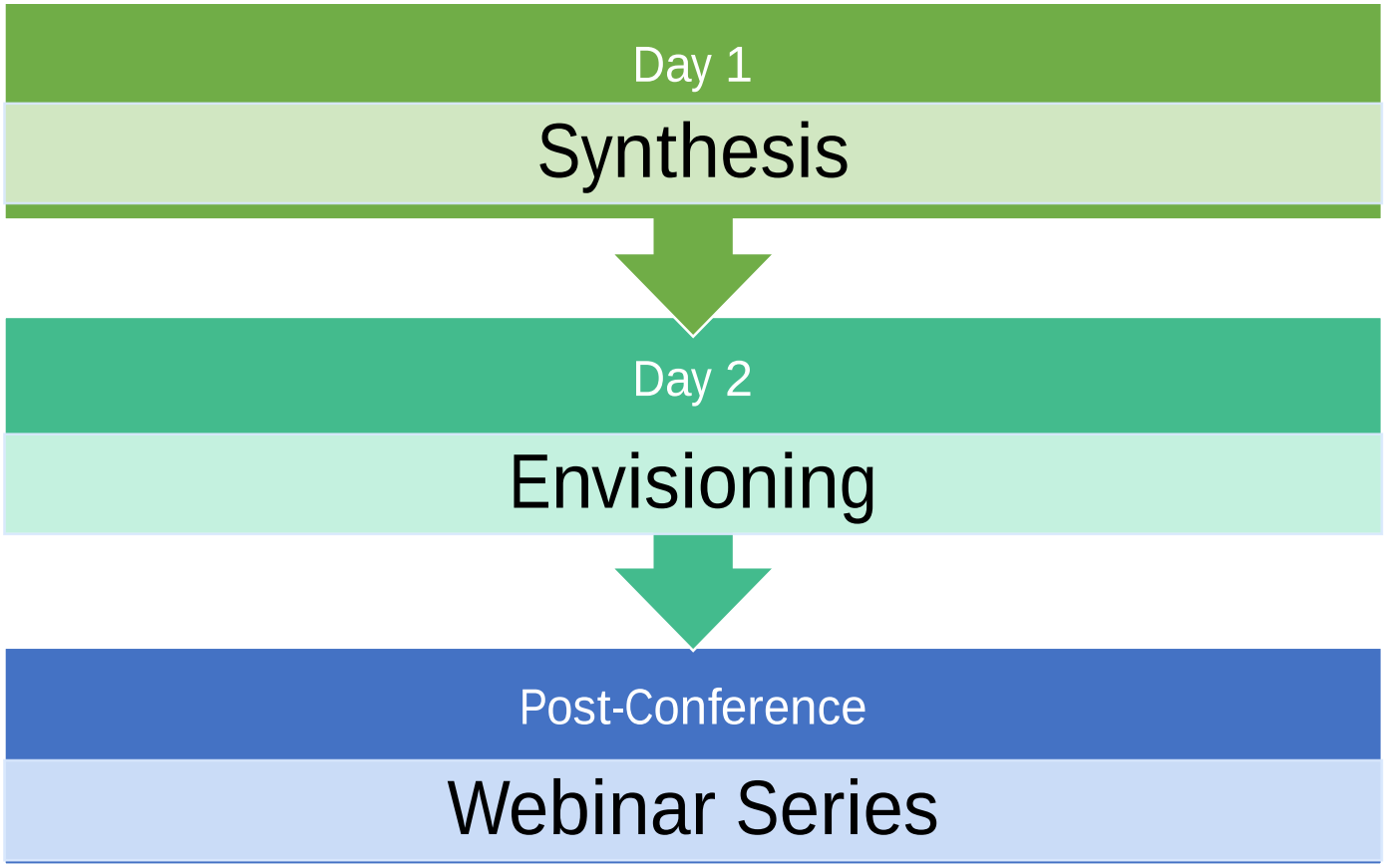
Structure of the Summit



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Today's presentations:

- Jennifer Albert, Citadel Military College of South Carolina
- Cynthia Tananis, University of Pittsburgh
- David Reider, Education Design

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For more information:

- Email the team at STELAR@edc.org
- Join us for the series:
  - **Webinar 4 - Broadening Participation,** Tuesday, May 14 from 2-3 pm ET
  - **Webinar 5: Partnerships,** Tuesday, May 21 from 2-3 pm ET

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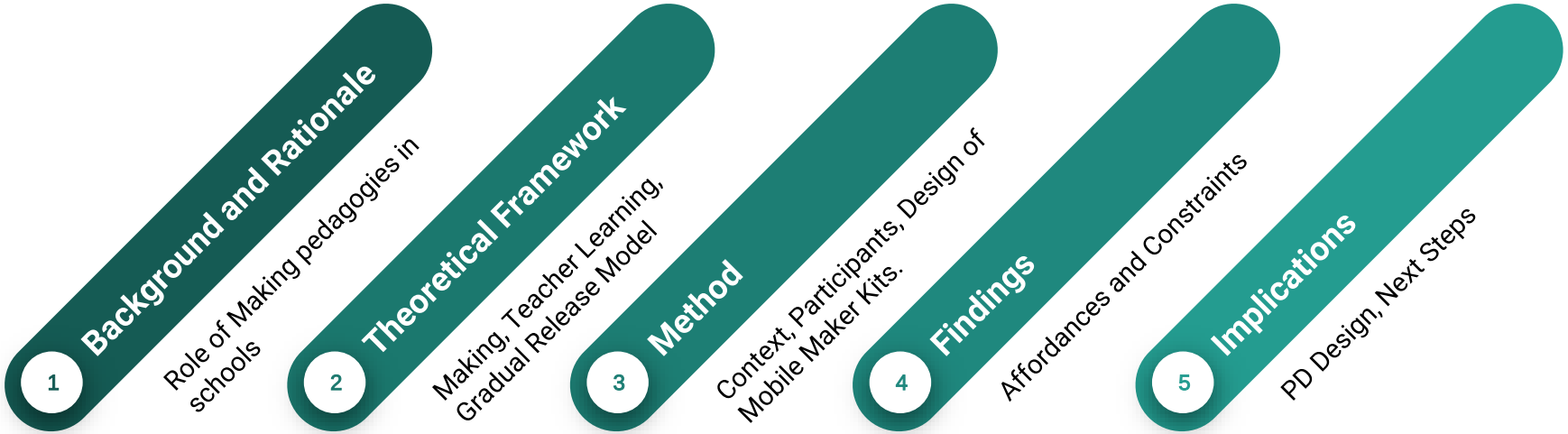
Scaffolding Pedagogical Change: Professiona Development to Support Elementary Teachers Implementing Mobile Maker Kits

Robin Jocius, Ashley Andrews, and Jen Albert
The Citadel

Presentation Overview



Background and Rationale

- Embedding active, inquiry-based Maker activities into classroom settings could potentially change conceptualizations of learning and teaching (Schön, Ebner, & Kumar, 2014)
- Dearth of research focused on supporting teachers to engage students with Making pedagogies, activities, and assessments (Halverson & Sheridan, 2014; Oliver, 2016)
- Research Question: **What are the affordances and constraints of a scaffolded, gradual release model to support teachers' integration of interdisciplinary, standards-based Making kits into their classrooms?**

Theoretical Framework

Theoretical Framework: Making

- Integrating Making into classrooms presents a complex set of challenges for teachers, who must navigate often contrasting disciplinary norms and practices, in addition to new interactional relationships with students (Halverson & Sheridan, 2014)
- Teachers must take on new roles as facilitators and enablers of student learning (Schön, Ebner, & Kumar, 2014), which may require a fundamental reshaping of their teaching practices and identities
- Veteran teachers do not easily “alter or discard” practices that they have developed over years in their classrooms (Guskey, 2002, p. 387)

Theoretical Framework: Teacher Learning

- Intensive professional development involving close collaboration between teachers and facilitators can support the process of pedagogical change (Darling-Hammond & Richardson, 2009)
- Key features to support pedagogical transformations
  - Varied exposures to new content and pedagogies (Grossman, Wineburg, & Woolman, 2001; Yoon, Duncan, Lee, Scarloss, and Shapley, 2007)
  - Ongoing collaborative discussion to address emerging problems of practice (Cohen & Hill, 2001)
  - Time to reflect and refine new practices (Clarke & Hollingsworth, 2002)

Theoretical Framework: Gradual Release M

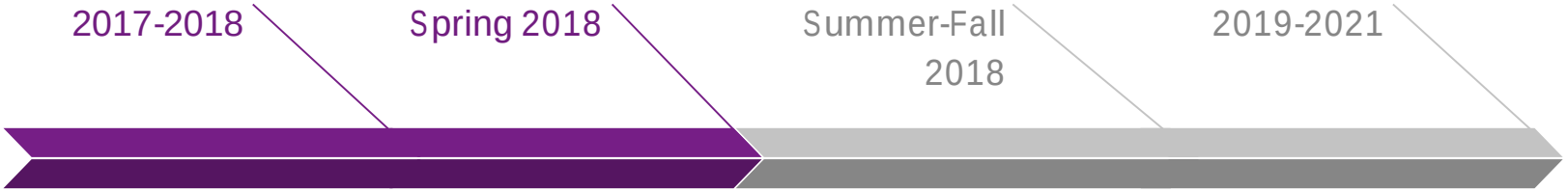
- Adapted from gradual release model for classroom instruction (Pearson & Gallagher, 1983)
- Positions “the teacher as an active constructor of knowledge” and allows “for appropriation of ideas through multiple interactions over time” (Collet, 2012, p. 44)
    - 1. Facilitator or coach models an instructional practice
    - 2. Facilitator collaborates with the teacher to co-construct and co-lead instruction
    - 3. Facilitator makes recommendations and affirms teacher decisions to push teachers towards increased responsibility and independence

Method

Mobile Maker Kits

- 2 year, NSF-funded research study to design, pilot, and integrate interdisciplinary, standards-based Mobile Maker Kits into 15 elementary schools within a suburban-rural Southern school district
- Design of 20 kits, which included lesson plans linking all activities and materials (e.g., picture books, craft materials, tablets, 3D printers, circuits and other electronic materials) to ELA, science, math, and social studies standards
- Lessons and resources available: http://www.mobilemakerkits.com/

Mobile Maker Kits: Timeline



Pilot

Collaborative design and testing of 6 Mobile Maker Kits in a 1st and 3rd grade classroom; video and audio recording, artifact collection

Data Analysis

Qualitative analysis of interviews, surveys, and artifacts (Charmaz, 2006) and multimodal discourse analysis (Norris, 2004)

Kit Design/Coach Training

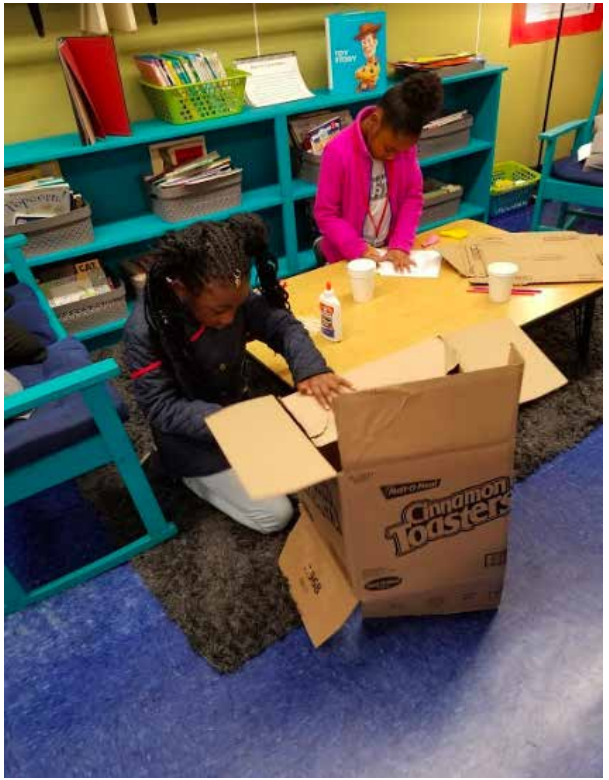
Design and adaptation of 20 kits for different grades, standards, and disciplines; training of 15 school-based coaches

Expansion and Comparison

Expansion to 15 elementary schools in a suburban-rural district; comparison across schools and informal/formal learning contexts

Context and Participants

- Creekside Elementary School
  - 805 students
  - 59% White, 27% African American, 13% Hispanic, and 7% two or more races
  - 50% of students receive free or reduced lunch
- Pilot teachers
  - Ellen, 1st grade, 7 years experience
  - Page, 3rd grade, 5 years experience
  - Both hold graduate-level degrees in Curriculum and Instruction and expressed interest in interdisciplinary instruction integrating Making



Gradual Release Model

December 2017

Revolutionary Circuits (3rd)

Shadow Puppets (1st)

Intended Teacher Role: Observe

February 2018

Solving Problems (1st)

Solving Problems (3rd)

Intended Teacher Role: Co-Lead

March 2018

Paper Slides (3rd)

Conserve Bumper Stickers (1st)

Intended Teacher Role: Lead

Data Collection and Analysis

- Data Sources
  - Video and audio recordings of Mobile Maker Kit lessons, teacher and student interviews, pedagogical artifacts created for the lessons, surveys measuring teacher beliefs and practices
- Data Analysis
  - Video and audio recordings analyzed using multimodal discourse analysis (MMDA) approach, which assumes that social interactions necessarily rely on forms of communication beyond language (Kress & van Leeuwen, 2001; Norris, 2004)
  - Interviews, pedagogical artifacts, and surveys analyzed using open coding to identify patterns across data sources and axial coding to coordinate and integrate categories and themes (Lincoln & Guba, 1985)

Findings

Affordance #1: Engaging in Transdisciplinary Design

- Initial interviews: Need for projects and curricular initiatives that incorporated key STEM and design thinking skills
- Ellen and Page: less than two hours total per week on science and social studies topics due to standardized testing pressures
- Page: “We don’t have time to do a lot with science. Or social studies. I haven’t had a lot of opportunities to see how to weave those into my lessons.”

Transdisciplinary Design Thinking: Revolutionary Ci

Standards	● Energy can be transferred from place to place by electric currents. Electric currents flowing through a simple circuit can be used to produce motion, sound, heat or light. (NGSS 4-PS3-4) ● People establish governments to provide stability and ensure the protection of their rights as citizens. (C3 Framework for Social Studies Standards; D2.Civ.4.3-5.) ● Authors use specific words, illustrations, and conventions to create mood, contribute to meaning, and emphasize aspects of a character or setting (CCSS.ELA-LITERACY.RL.3.7)
Lesson Phases	1. Hook: Padlet responses, reflection, text reading and response 2. Brainstorm: Energy stick demonstration, review of sample circuits and templates, drafting spy message 3. Prototype: Spy message creation, testing, revision 4. Share and Synthesize: Presentations, interactive discussion, exit ticket
Materials	● Padlet or Post-Its, Anticipation guide, Francis Marion book, Energy stick, Paper circuits (Copper tape, 3V coin cell batteries, Surface mount LEDs, Binder clips, Model circuit paper, Paper materials to make letters/cards, Crayons, markers, etc., Sample circuits

Transdisciplinary Design Thinking: Student Engager

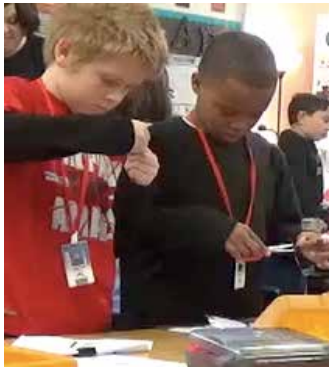
Alice: So, that didn’t work. This one goes on the long side and this goes on the short side.
Calvin: They can't touch.
Alice: Ok. So, it doesn't feel like there's really tape on this.
Calvin: So, like this? What's that for? Fold here. (holds copper tape out for Alice).
Alice: Is it working?
Calvin: Look, it's glowing.
Alice: It's glowing. It shows the other spies where the weapons are!
Calvin: Maybe we should add a symbol on the map to hide where it is, like the Swamp Fox.

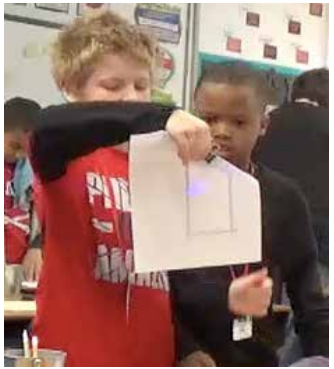
Affordance #2: Scaffolding Failure

- Kurti, Kurti, and Fleming (2014) even discuss “failure” as one of the guiding principles of makerspaces and “simply the first or second or third step toward success” (p. 10)
- During open-ended Making projects, there is a high likelihood that students will experience failure in order to advance a project, which is contradictory to more traditional forms of teaching and learning.
- Gradual Release model introduces Ellen and Page to unfamiliar and potentially uncomfortable pedagogical practices, such as teaching students to embrace failure in the service of Making

“I Don’t Want to Mess This Up”: Scaffolding

Ezekiel: Look at this, it looks so terrible. I can’t fit the tape in for the circuit.
Adam: I think we have to start over.
Teacher (walking over to boys): Oh my goodness, this looks great.
Ezekiel: It looks terrible. Am I doing it right?
Teacher: It looks great!
Ashley: So, did you do one and you're doing one? So, you have your idea down. It doesn't have to be done, because this is just your draft, right? But it looks like you have a good idea. Should we try the next step?
Adam: *Is that okay?*
Ashley: Of course! So, what we're going to do is this, you're going to use this as a template to help you. It's called copper tape, so it's going to help the electricity move on the page.
Adam: So, the copper is the thing that helps it light up?





Constraints

- Lack of explicit training in favor of a coaching model
  - Page: “I am curious about how a teacher knows what components to add to a maker lesson and why. I would want a breakdown of each part and how it helps the kids.”
- Failure to fully draw upon teachers’ resources and knowledge of students
  - Ellen: “The maker lessons had great ideas but they needed to be spread out. I like to use the mentor texts and allow them to have time to generate ideas days before they started making. That way, they really understand the standards and story elements and they don’t get lost while making.”

Implications

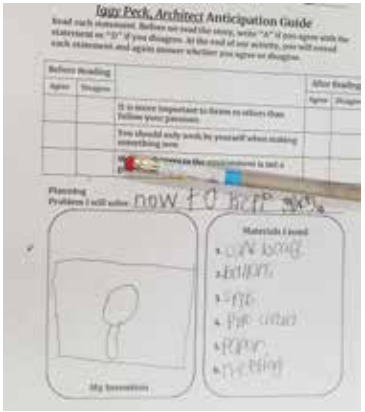
Implications

- Teachers need explicit training and opportunities to recursively create and revise lessons with support from facilitators
- Need to develop and test flexible, incremental supports
  - Website for accessing and using resources: www.mobilemakerkits.com
  - Just-in-time coaching activities initiated by teachers
  - Opportunities to engage in asynchronous and synchronous discussions with other educators using the Mobile Maker Kits
  - Incentives for teachers to design Mobile Maker Kit lessons to share with their colleagues.

Future Research

- Analysis of interactions, questions, responses to teacher coach PD
- Studying impact of flexible, just-in-time supports
- Microanalysis of teachers' videotaped lessons
- Studying role of teacher coach and administrative support in kit integration

Thank you!



“As educators, we've put education in a box and the makerspace takes it out of the box. Especially with the kids because they learn by discovering and they internalize by discovering, not sitting at a desk listening to someone else.”

Page, a 3rd grade teacher

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Researching a School District's Integration of the Maker Movement into Its Middle and High School

Keith Trahan, PhD, Cindy Tananis, EdD, Stephanie Romero, EdD, Renata de Almeida Ramos, MEd, Everett Herman, PhD, and Jeffery Zollars, EdD

This NSF:EAGER:MAKER research project is a mixed-methods, case study to articulate why and how the Elizabeth Forward School District (EFSD) integrated the Maker Movement into its secondary schools, and to consider selected outcomes:

- Changes in space and culture
- Student engagement
- Teacher engagement

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Elizabeth-Forward School District

Semi-Rural/Suburban public school district 20 miles southeast of Pittsburgh, Pennsylvania.

Population = 18,140 (Census 2010).

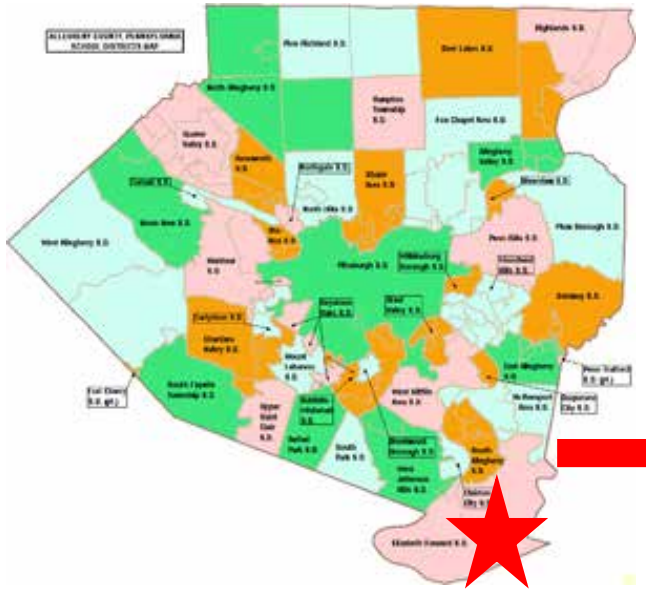
Average median household income = $45,735 (2011-2015 estimates for Census Bureau)

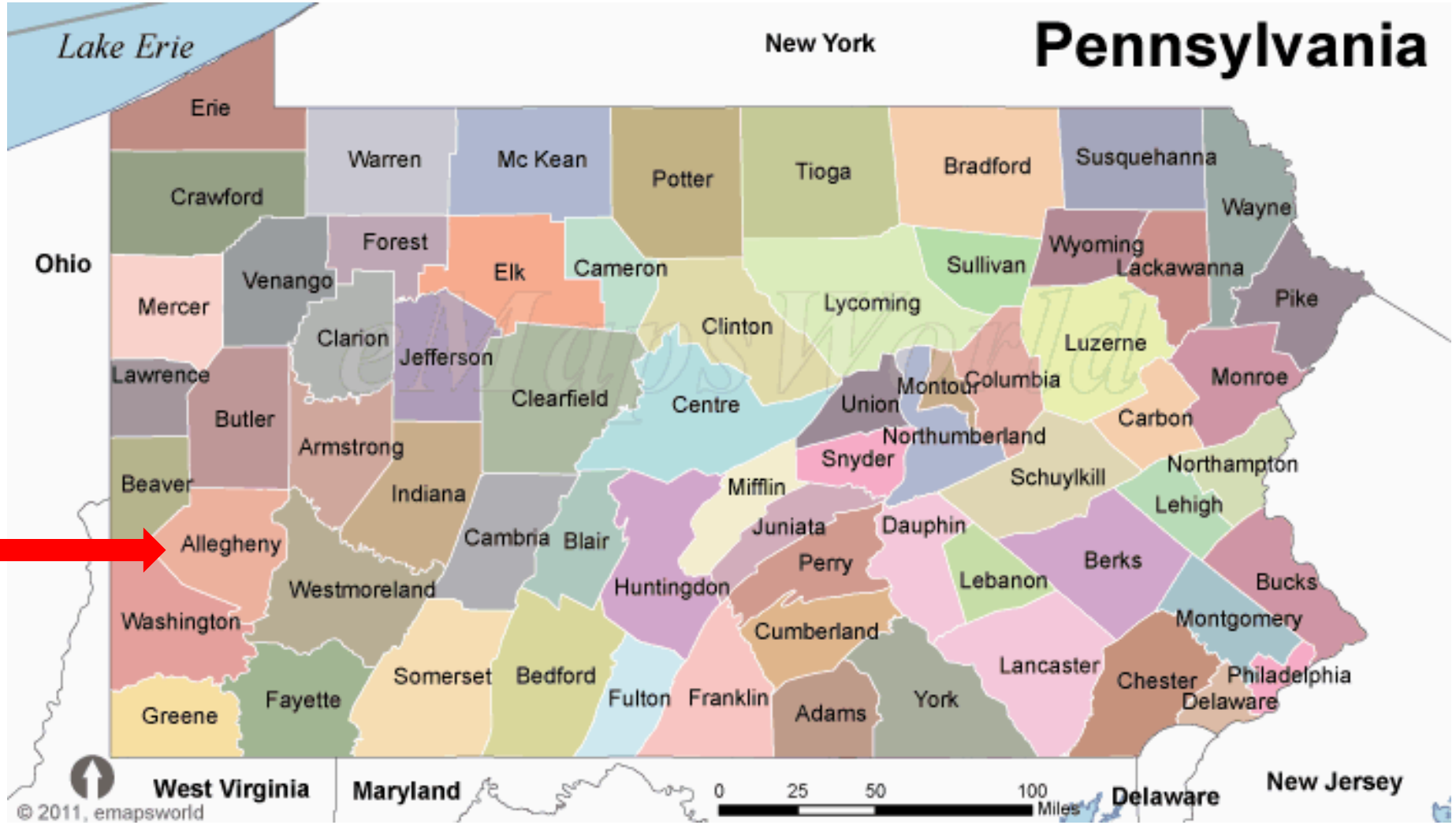
- Allegheny County median household income = $53,040 (2011-2015 estimates for Census Bureau).

202 teachers; 106 full & part-time support personnel; 12 administrators.

Enrollment for 2015-2016:

- Middle School (MS) : 508 pupils;
- High School (HS): 766 pupils;
- Total: 1,274.

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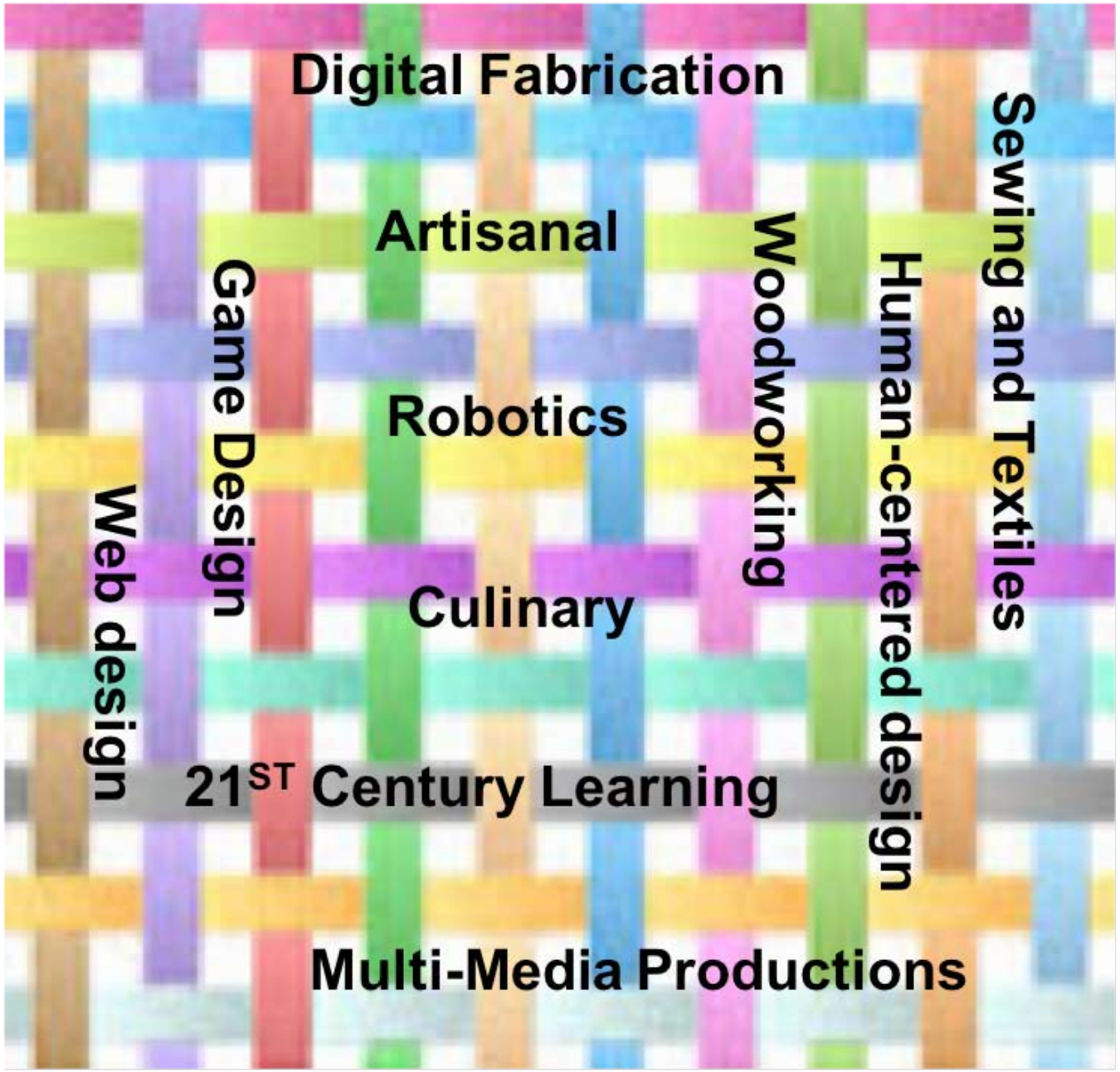
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Robotics
Culinary
Multi-Media Productions
21ST Century Learning
Web design
Game Design
Woodworking
Human-centered design
Sewing and Textiles


Dream FACTORY
SCHOOLS
TO
WATCH
WHERE EVERY CHILD COUNTS!
Dream FACTORY


Allegheny Educational Systems
FAB LAB


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Theoretical Framework

A Constructionist/Constructivist Approach to Education:

"Adults, as well as children, learn through the processes of meaning and knowledge construction, inquiry, participation, and reflection. The function of leadership must be to engage people in the processes that create the conditions for learning and form common ground about teaching and learning" (Lambert, 2002).

Schools that Learn:

"In our view, a learning school is not so much a separate place … as a meeting ground for learning—dedicated to the idea that all those involved with it, individually and together, will be continually enhancing and expanding their awareness and capabilities" (Senge, 2000).

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Elizabeth-Forward Goals:

- Improve/Enhance instruction and learning
- Increase engagement
- Provide students more opportunities
- Modernize classrooms/schools
- Prepare students for 21st century/workforce
- Bring success and recognition to the district and its schools

Administrative Vision

”It’s not about the *Making*. It’s about having things to create a culture of learning for kids, to give kids opportunities to engage in.”

”How do we better our lessons…. how do come up with more creative, engaging lessons…. that’s sort of how innovation started.“

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Research Questions

1. What are the characteristics and capacities of EFSD's integrated Maker Movement and which are critical for success?
    - Facilities Inventory
    - Documentation
    - Interviews
    - Surveys
2. How has EFSD's integrated Maker Movement generated a productive nexus of informal and formal education?
    - Documentation
    - Interviews
    - Surveys
3. What is the effect of this integrated Maker Movement on student and teacher learning, confidence, and capacity in STEM?
    - Interviews
    - Surveys
    - Observations
    - Student course taking and attendance data, grades, and standardized test scores (12^{th} grade)

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Findings: It takes a village. People. Culture. Process.

Integrated Making Framework

PEOPLE

- Leadership
- External Networks, Partnerships, and Support
- Personnel

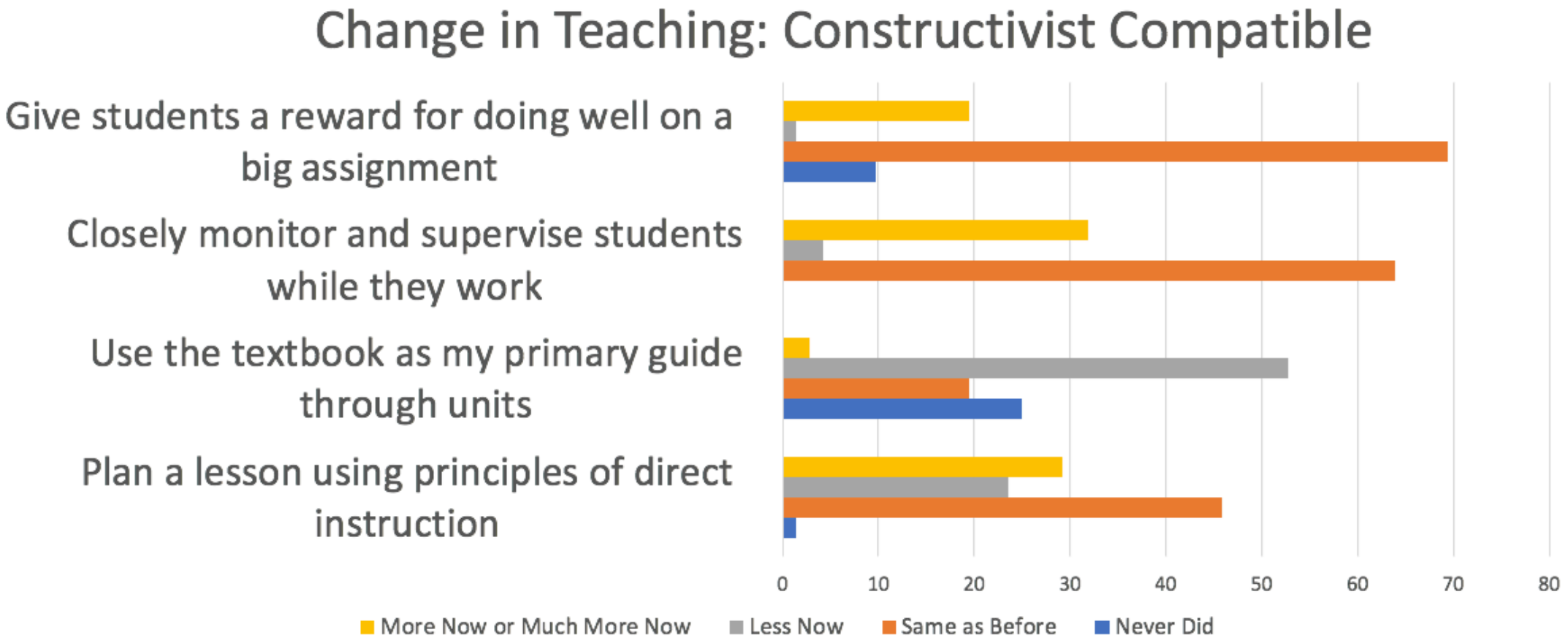
CULTURE

- Risk taking and the freedom to fail
- Collaboration
- Learning

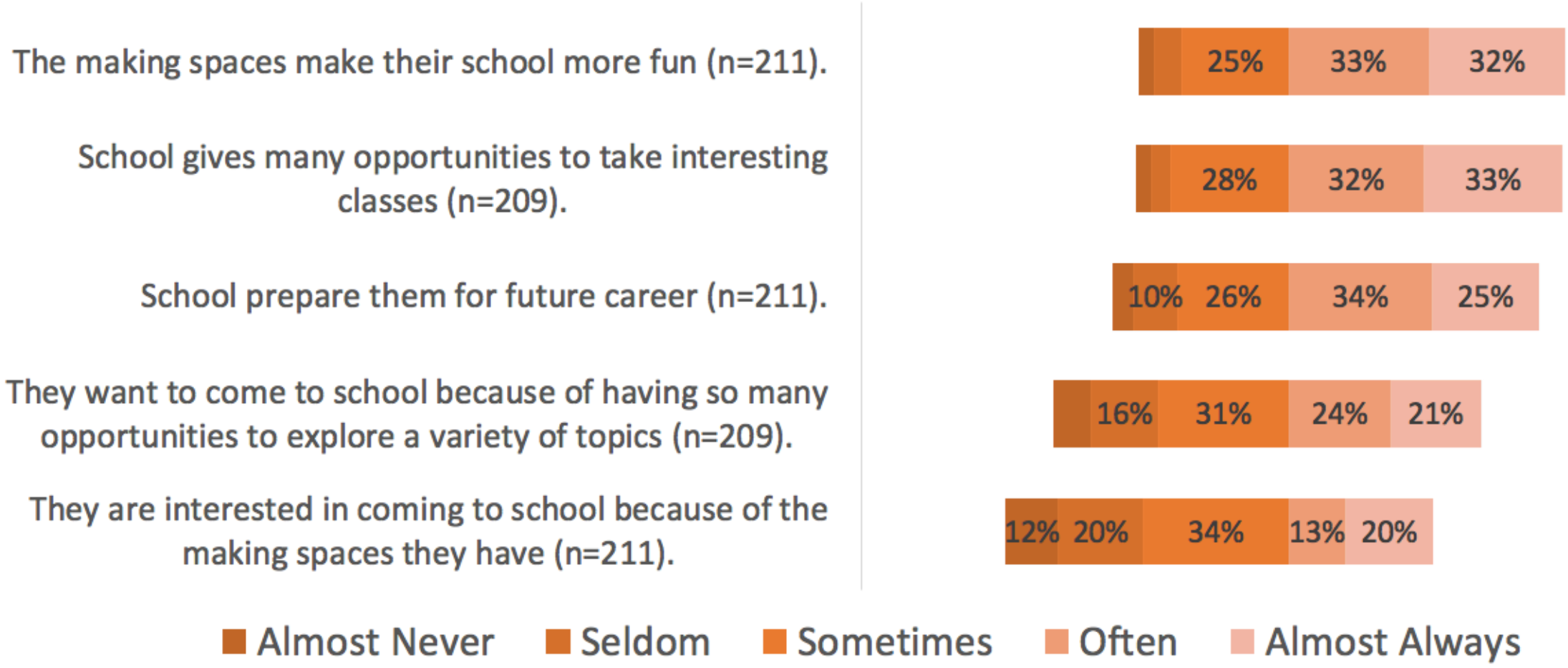
PROCESS

- Professional learning
- Facilities and technology
- Structure of schooling
  - Classes and curricula
  - Time and schedules

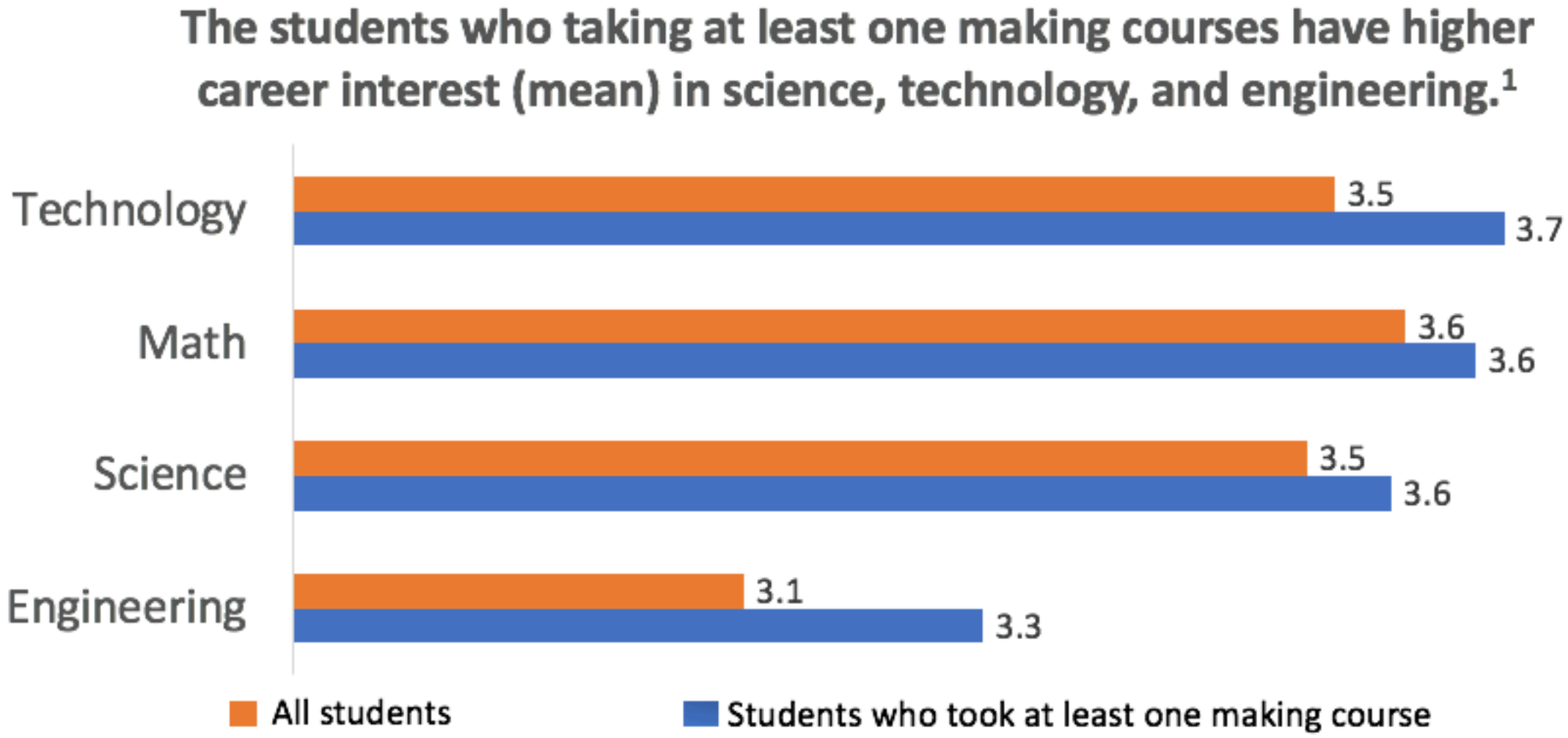
Findings: Maker initiatives promote change in teacher practices towards more constructivist-compatible instruction. Teachers construct and reconstruct their own knowledge on how to teach and reach students.



Findings: Students experience constructionist learning environments that promote creativity, initiative, and exploration. Students want to come to school more



Findings: Students show higher interest in STEM careers



Research "Measurement" Issues

- **Complexity of capturing process** (retrospective, describing the elephant from various perspectives, refined memory may reflect inaccuracies)
- **Teacher AND Student self-report and reflection**:
  - Accuracy
  - Rewriting history after change
  - Locus of control
  - Highly individualized process
  - Understanding the relationship between making and learning, innovation and development of higher order expertise
- **Flow**:
  - Hard to capture and measure
    - Indirect observation
    - Direct report requires interrupting the flow itself, defeats the instructional effort and changes the perception to retrospective

Researching a School District's Integration of the Maker Movement into Its Middle and High School

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Research and Evaluation

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EDC Education Development Center

Day 1 – Synthesis: The State of Making

- Explore the innovations and challenges that currently exist in Making projects
- Share dreams and aspirations for the future of making

Day 2 – Envisioning: Call to Action

- How do we get from where we are now to where we want to go?
- How can NSF support Making projects in working towards these goals?
- Identify gaps in the current body of research

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Synthesis: Challenges

- Mismatch with stakeholder needs
- Lack of consensus in terminology and definitions, specifically should we define “Making”
- Numerous, often disjointed, desired values
- Not yet building knowledge
- Defining the purpose of research (e.g., funding, workforce development, engagement, STEM interest)
- Quality and quantity of assessments

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Synthesis: Innovations

- Needs analysis (What do Makers projects want to know?)
- Landscape report
- Innovative instrumentation (e.g., Beyond Rubrics)

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The Future of Making

- Thinking about how Making prepares for the future workforce (and how to prepare research and evaluation to address such changes)
- Develop embedded, real-time, formative assessments/feedback
- Extend the library of resources around Making
- Explore roles in Making and how they evolve over time
- Developing a culture of improvement (e.g., defining outcomes, terms, shared challenges)
- Breadth and depth of differentiated research

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Envisioning: The Path Forward

- Building capacity in the field
- Engage with practitioners as researchers
- Explore the intersections of research practices

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Envisioning: Call to Action

- Development, implementation, and revision cycle of innovative instruments/assessments (both cognitive and non-cognitive)
- Develop a definition of Making and list of associated terms with definitions
- Possibilities:
  - Conference ideas/interest
  - Joint proposals
  - Publications

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Questions?

Comments?

Ideas?

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STEM LEARNING AND RESEARCH CENTER

For more information:

- Email the team at STELAR@edc.org
- Join us for last two webinars of the series:
  - Webinar 4 - Broadening Participation

    Tuesday, May 14 from 2-3 pm ET
  - Webinar 5: Partnerships

    Tuesday, May 21 from 2-3 pm ET

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