



# Research + Practice Partnerships: The California Tinkering Afterschool Network

This case study of the California Tinkering Afterschool Network (CTAN), a Research + Practice Partnership (RPP), provides a detailed account of how a local RPP, within the auspices of the Research + Practice Collaboratory (RPC), organized their partnership and their work, and what the benefits of that work have been. It documents how researchers and practitioners negotiate this work, and provides examples of the structures, tools, and routines that the partners use to mediate the process. The case highlights what was meaningful for researchers and practitioners, and illustrates where there were differences and overlap between researchers' and practitioners' perspectives on critical moments in the development of the partnership. Also documented here are the multiple benefits of the work of the local RPP and the broader RPC to a wide range of stakeholders and audiences.

This case focuses on the design and functioning of the partnership, with attention to several focal points of special interest as outlined in the Sections below.

Section I. **An overview of the CTAN project** and a summary of CTAN's activities.

Section II. **The conception, initiation, enactment, and evolution of the RPP**, focusing on the roles that researchers and practitioners played in decision-making and defining the work.

Section III. **The inquiry of common interest—its designation and evolution**, describing how the problem or inquiry was framed, has evolved, and been deemed important.

Section IV. **The relationships and interactions between researchers and practitioners**, portraying the roles and dynamics between the individuals involved.

Section V. **The multiple benefits of the CTAN RPP and the RPC**, considering the immediate and long-term outcomes of the work of the RPP.

Section VI. **The case as illuminative of design-based Research + Practice Partnerships**, reflecting on the CTAN work in the larger context of the Collaboratory effort.

## The Research + Practice Collaboratory

The Research + Practice Collaboratory (<http://researchandpractice.org>) aims to explore and demonstrate ways that research and practice, and researchers and practitioners, can interact in a variety of non-traditional ways to support educational improvement. The original vision communicated to NSF: "The challenge is not how to create better or more devices or artifacts that translate research to practice but rather how to create richer opportunities for cultural exchanges between communities of research and practice" (Coburn & Stein, 2010). The Collaboratory created the concept of "adaptation sites," later called "local labs," to identify local STEM improvement projects where researchers and practitioners in a range of educational settings would partner for the purpose of creating such contexts for cultural exchanges leading to new knowledge and improved practices.

Inverness Research conducted multi-year case studies of the research-practice partnerships deemed "local labs" for the Collaboratory. The cases aim to portray details of the leadership, design, and implementation of the partnerships, and to offer reflections on key features that shaped the interactions and work of the joined communities of research and practice.

# I. OVERVIEW

The Research + Practice Collaboratory formed a Research + Practice Partnership called the California Tinkering Afterschool Network (CTAN), which brought together practitioners (leaders, directors, facilitators, and line staff) working in the afterschool domain with educational researchers from the Exploratorium. A primary purpose of the CTAN RPP was to involve the voices of practitioners in the acts of 1) testing and adapting research findings relevant to the afterschool and Tinkering contexts, and 2) designing, implementing, and studying STEM-Rich Tinkering opportunities in afterschool settings serving traditionally under-served youth. The partners came together because they believed in the power of STEM-Rich Tinkering to make learning more accessible to diverse youth.

## STEM-Rich Tinkering

In open-ended inquiry, learners develop their own idea or goal and figure out how to accomplish it. This is sometimes called Tinkering because it emphasizes creative, improvisational problem solving. STEM-Rich Tinkering involves a playful, collaborative, and problem-solving approach to deep investigations of scientific phenomena that let learners' ideas and aesthetics shine. In STEM-Rich Tinkering, young people develop their understanding and interest in scientific phenomena, like circuitry, while engaged in scientific and engineering practices such as designing, building, testing, and revising battery-operated Scribbling Machines.<sup>1</sup>

This partnership was formed to investigate and document the design features, principles, and supports that shape effective facilitation and implementation of STEM-Rich Tinkering in afterschool contexts, so that these features and supports could be developed, nurtured, and sustained. In interviews, Bronwyn Bevan, the Director of CTAN, described it as follows:

*A network of science-rich organizations—all of which provide programs to afterschool partners or provide programming at their sites. The network was formed for this group of science-rich institutions to develop STEM-Rich Tinkering programs for afterschool settings serving low-income communities and to understand, and then more broadly document and disseminate, the key features and what it takes to implement those features...in order to inform a broader scale-up of Tinkering into after school programs in low-income communities.*

CTAN was officially led by the Exploratorium in San Francisco, with the following primary partners: Community Science Workshops (in Watsonville and Fresno), Discovery Cube (Discovery Science Center) in Santa Ana, and Techbridge in Oakland. CTAN advisors included representatives from the California Department of Education Afterschool Division, Kris Gutiérrez (UC Berkeley), and Bill Penuel (CU Boulder). What follows is a brief description of each partner organization, their work with afterschool sites, and their involvement in CTAN.

## Partners

**The Exploratorium, San Francisco:** The Exploratorium is a museum of science, art, and perception that has served as a flagship institution in informal education for nearly 50 years. With over 600 interactive exhibits, the Exploratorium is popular among families and friends; in addition, it provides professional development for teachers, and serves as a field trip destination for many school-age

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<sup>1</sup> From <https://www.exploratorium.edu/education/california-tinkering-afterschool-network-about>

children in the Bay Area. For almost two decades, the Exploratorium has housed the Tinkering Studio, which provides museum-based STEM-Rich Tinkering programs, community programs in partnership with the SF Boys & Girls Clubs, and professional development for educators around the country and internationally. Playful in nature, Tinkering involves creative and improvisational problem solving through designing and building. The Exploratorium is a leader in providing Tinkering professional development programs and resources for the field.

Prior to the Research + Practice Collaboratory, the Exploratorium was the hub for a professional development network that focused on Tinkering, equity, and learning. Bevan, along with Mike Petrich and Karen Wilkinson of the Tinkering Studio at Exploratorium, hosted professional development gatherings that brought together several of the organizations that would later form CTAN. The Exploratorium also initiated a research-practice partnership between Shirin Vossoughi, who had a postdoctoral appointment with Bevan, and Meg Escudé, who was hired to launch afterschool programs at the Exploratorium.

When the larger Research + Practice Collaboratory was formed, these previous Exploratorium-based initiatives were well-positioned to form the foundation of the CTAN Research + Practice Partnership, supported by RPC funds. With new funding from NSF, Bevan added research capacity to the network by initiating research in the other partner sites, following methods developed in the earlier RPP. The research team consisted of Molly Shea who worked primarily with the Community Science Workshop (CSW) Network sites in Watsonville and Fresno, Jean Ryoo who worked primarily with the Discovery Cube in Santa Ana and Techbridge in Oakland, and Nicole Bulalacao who worked as a research assistant to Jean Ryoo at Techbridge and who also provided project coordination support to the Collaboratory. In addition to her research, Ryoo served as Researcher and Project Director for CTAN.

**Community Science Workshops in Watsonville and Fresno:** The Community Science Workshop model was born in Dan Sudran's garage in 1991. He was living in San Francisco's Mission district among a large population of children born to first-generation immigrants whose primary language was Spanish. Every day, children would stop in to Sudran's garage to interact with him and with the many tools and gadgets that he was working with. This activity inspired the Mission Science Workshop (MSW), now housed in the former auto-shop at Mission High School in San Francisco.

There are four core characteristics that define the CSW model: it must be located in a neighborhood; it must be open-ended, exploratory, and student driven; it must be open-door, usually free, and provide drop-in hours during the day, afterschool programs, field trips, and mobile programs; it must bring science to the community, working with schools, housing projects, libraries, parks, etc., and with people of all ages. Over 20 years, this model has expanded to other locations, forming the current Network of six sites in California: Watsonville, Fresno, Greenfield, Sanger, and two in San Francisco (Mission Science Workshop and Excelsior Science Workshop). The Watsonville and Fresno sites were most directly involved with CTAN. Emilyn Green was the Executive Director for the Community Science Workshop Network during much of the CTAN work. José Sandoval was the Site Director for the Environmental Science Workshop in Watsonville. Manuel Ibarra Hernandez directed Fresno Community Science, and Jerry Valadez directed the Sanger Community Science Workshop nearby. Molly Shea was the CTAN researcher collaborating with the CSW sites in Watsonville and Fresno as well as with the CSW Network leaders.

**Discovery Cube (aka Discovery Science Center) in Santa Ana:** Discovery Cube Orange County is one of two informal science centers (the other is in Los Angeles) managed by the Discovery Science Foundation. Four key interests for the Foundation—STEM Proficiency, Early Learning, Healthy Living, and Environmental Stewardship—are at the core of the initiatives carried out at Discovery Cube, through hands-on exhibits, school programs, afterschool workshops, outreach programs, and professional development programs and resources for educators. Discovery Cube prioritizes aligning its programs with the Next Generation Science Standards and State Science Content Standards.

Paul Pooler is the Director of Education for off-site programs at Discovery Cube in Santa Ana, and he was the principal staff member who participated in CTAN. At Discovery Cube, Pooler works with all of the outreach programs, including those focused on Tinkering, and oversees a staff of eight educators (five full-time and three part-time). He conducts professional development for both afterschool and in-school educators in programs such as iCREATE, while collaborating with organizations such as the San Bernardino Community College District. It is in this context that Pooler and his CTAN research partner, Jean Ryoo, focused their attention on understanding the professional development supports that are necessary to provide high quality, STEM-Rich Tinkering.

**Techbridge in Oakland:** Techbridge started in 2000 as a program of the Chabot Space and Science Center in Oakland, California. The aim of Techbridge is to broaden academic and career options for girls in science, technology, and engineering. The program provides a suite of resources for educators, families, potential role models, and schools and school districts. In 2011, Techbridge became its own entity, continuing to focus on girls and underrepresented minorities in STEM fields.

Techbridge operates in three Bay Area school districts and collaborates with 20 Girl Scout councils around the United States. It has recently expanded to offer programs in Seattle and Washington DC. Techbridge provides professional development for afterschool and summer staff to facilitate inquiry-based activities for girls, curriculum, and extra resources.

For most of CTAN's work, Linda Kekelis was Chief Executive Officer and Executive Director of Techbridge and directly oversaw programs for girls (both afterschool and summer programs) and professional development for partner organizations such as the Girl Scout Council and afterschool staff in school districts around the Bay Area. Emily McLeod is the Director of Curriculum at Techbridge. Ben Henriquez joined the organization in July of 2014 and was the Professional Development Coordinator. Jean Ryoo was the researcher collaborating with Techbridge, together with Nicole Bulalacao, who played a research assistant role on site visits.

**California Department of Education Afterschool Division:** Consultant Johannes Troost served as the California Department of Education's primary point of contact for the CTAN project before being reassigned. Troost attended the first Inquiry Group meeting on Cross-Setting Learning in February 2014. The Director of the Afterschool Division, Michael Funk, attended the two-day Inquiry Group at the Exploratorium on equity in out-of-school STEM learning in January 2015 (find the report describing the meeting at <http://researchandpractice.org/resource/equity-inquiry-group/>). Staff from the Afterschool Division who oversee the state's 21<sup>st</sup> Century Community Learning Centers program also attended a three-day Tinkering in afterschool professional development workshop in March 2015.

## Participants and Audiences

Because of the number of different organizations and programs involved in CTAN, this RPP had a broad sphere of influence. However, its predominant focus was children and teachers from under-served, under-represented schools and communities. At Community Science Workshops, the participants are both drop-ins from the neighborhood as well as students in schools. Techbridge offers afterschool and summer programs for girls from the San Francisco Bay/Oakland and Seattle regions as well as professional development for afterschool staff. Discovery Cube provides afterschool programs, serves as a field trip destination, and has several outreach programs. The Exploratorium works with Boys and Girls Clubs serving students from low-income areas in San Francisco.

## Overview and Chronology of the Work and Products

Following is a description of the general phases of the CTAN work and the lab's overall trajectory.

### Initial relationship building and goal setting

CTAN as an RPP was initially molded by two influences. Leaders from two of the organizations (Bevan from the Exploratorium and Kekelis from Techbridge) had worked in parallel for several years, meeting at conferences, respecting one another's work, and had looked for future opportunities to work together. In addition, a funding agency suggested that one of the leading institutions would benefit from having more partners. During 2012, the five organizations worked together to experiment with and document the integration of Exploratorium Tinkering Studio activities in each of the respective programs. This culminated in video documentation, including, in some cases, student interviews of other students (Techbridge), program interviews of parents and children (Fresno), and program leader videos of youth learning, which were analyzed to create a framework that linked Tinkering to STEM Practices and 21<sup>st</sup> Century Skills (see evaluation in Bevan & Michalchik, 2013).

Leaders from four partner sites (CSW, Techbridge, Exploratorium, and Discovery Cube) worked together for approximately one year in a professional development network, which was evaluated by SRI International. The following year, the group worked to secure a second phase of funding from the S.D. Jr. Bechtel Foundation, which would ultimately coincide with the funding for the RPC. Following the hiring of Exploratorium-based field researchers, the partner sites proposed to re-launch the collaboration with a stronger research focus and thus, CTAN formed as a research-practice partnership.

CTAN members participated in phone calls in January 2014, with the purpose of getting to know one another better and to discuss their understandings of the proposed work, as well as their perceptions of partnership. Later in the same month, partners attended the RPC inquiry group meeting at the Exploratorium, which was followed by the official CTAN Kick-Off meeting at Techbridge in February 2014. Here they dove into Design Based Implementation Research (DBIR) by surfacing and discussing partners' values (through a Value-Mapping activity), beliefs, and understandings in order to identify and refine conjectures and research questions. Practitioner leaders from all partner sites and researchers from the Exploratorium were all in attendance at this meeting.



## Ongoing relationship building, data collection, collaboration, and RPC work

In the following months, researchers conducted exploratory observations of CSW, Techbridge, and Discovery Cube programs and worked to develop relationships with “front line” staff (afterschool facilitators) and better understand the contextual factors present in each of the different sites. Soon, researchers were interacting regularly (weekly or biweekly) with leaders and staff at each of the partner sites.

Throughout this phase, every month from March 2014 through all of 2015, CTAN members also participated in conference calls together. On these calls, participants would discuss pressing issues, data collection, and collaborative Network activities, and continue to refine their definition of equity—both for their own work as well as the work with participants in afterschool settings. These calls would also bring to light other opportunities for members of the Network to collaborate, such as workshops, blogs, conference presentations, and papers.

Summer and fall of 2014 were busy seasons for CTAN data collection, as well as collaborative programming and analysis. On June 23-24, 2014, leaders from CTAN partner organizations met at an RPC meeting in Boulder and continued their discussion of equity. They were also invited to attend the ICLS (International Conference of the Learning Sciences) meeting following the RPC gathering. CTAN partners participated in a July 29-31, 2014, Tinkering Workshop hosted by the Exploratorium. This workshop was offered to a range of practitioners, not solely CTAN members; however, CTAN-specific debrief meetings were held at the end of the day on July 29 and 30. Several CTAN partners also attended a dinner following the Tinkering workshop. On July 31, CTAN held a shorter debrief meeting, which took place within the context of the larger workshop.

### Timeline and Components of the CTAN RPP

	Professional development	Planning	Data collection	Data analysis	Meetings	Dissemination
2012	X	X				
2013		X				
Winter 2014		X			X	
Spring 2014		X	X			
Summer 2014	X	X	X	X	X	X
Fall 2014		X	X	X	X	X
Winter 2015			X			X
Spring 2015			X			X
Summer 2015			X			X
Fall 2015						X
Winter 2016						X

Both CSW and Techbridge offered professional development programs in summer of 2014, which provided a number of collaboration opportunities for CTAN researchers and practitioners. These opportunities would result in a collaborative review and discussion of Techbridge’s summer offerings, involving a researcher, two program leads, and front-line facilitators. As a result of this review, Techbridge developed a list of best practices for facilitation that would be shared with the rest of the CTAN network. Meanwhile, the CSW Network held its own retreat in late August 2014 where they implemented three activities relevant to the work of CTAN with their own staff and facilitators; the Value Mapping activity from CTAN, the Chain Reaction activity from the July Tinkering workshop at Exploratorium, and a *Teatro* discussion from a CTAN call.

On September 11, 2014, CTAN held a meeting at the Exploratorium with leads and front-line staff from each partner organization: at this meeting, they continued their discussion of equity, developed the concept of facilitation muscles (the skills and strengths needed to provide strong equity-oriented facilitation), began to reframe the notion of “failure,” provided feedback on emerging conjectures, and outlined ideas for resources to share with broader audiences.

### **Broadening CTAN’s efforts and sharing the work**

CTAN researchers and practitioners began to disseminate the results of their efforts beginning in late 2014, though data collection continued through the summer of 2015. At the annual meeting of the Association of Science and Technology Centers (ASTC) in October 2014, CTAN members conducted a joint presentation, which advocated for researchers and museums sustaining ongoing partnerships with community organizations as a long-term strategy to address equity issues—as opposed to one-off outreach efforts through which museums or researchers offer “solutions” to local challenges.

Prior to an RPC Inquiry Group meeting (the focus of which was “Equity-Oriented Facilitation Strategies in Out-Of-School-Time STEM programs”) on January 30-31, 2015, CTAN partners met as a network on Jan. 29, and advanced their work on facilitation muscles to share with a wider audience of experts across the country for feedback. Researchers from the Exploratorium also published a report on the equity Inquiry Group meeting itself. In late winter 2015, CTAN partners participated in a U.S. Department of Education/Institute for Museum and Library Services project to inform the practices of afterschool programs around the country. This work resulted in a video featuring Community Science Workshops.

Late winter and spring of 2015 were very productive seasons for CTAN in the development and dissemination of tools for publication on the RPC and CTAN websites. These tools included resources for Value Mapping activities (<http://researchandpractice.org/resource/value-mapping/>), a reflection tool, and an iteration tool (<http://researchandpractice.org/resource/iterations-drafts-workshop-guide/>). In April 2015, the leader of Techbridge and her partner researcher published a blog post on iteration, “failure,” and Tinkering (<http://corwin-connect.com/2015/04/the-other-f-word-making-sense-of-failure-and-nurturing-resilience/>). CTAN partners also presented a poster at the annual conference of the American Educational Research Association (AERA) in Chicago during the same month. May of 2015 signaled the return of the Maker Faire in San Mateo, where CSW and Techbridge were exhibitors, with students sharing their work with visitors. These latter two events are

particularly notable because the AERA conference primarily involves researchers, and the Maker Faire primarily involves practitioners. Through CTAN, researchers and practitioners worked together in both contexts.

On May 28-29, 2015, CTAN partners (two practitioners and a researcher) led an RPP-funded meeting at the Exploratorium: “Developing Tools that Help Build Equity into Research + Practice Partnerships,” to develop tools and resources to build equity into RPP relationships and projects. These resources were published on the RPC and CTAN websites. In addition, CTAN partners created a game, which was published in 2016. June 2015 marked the launch of the official CTAN website where resources are shared with a larger audience. Around that time, researchers and practitioners also worked together to develop and implement two webinars on RPPs through the Afterschool Alliance.

Formal data coding began in the fall of 2015 and was completed in January 2016. Also in fall of 2015, CTAN partners wrote a research paper for (and two practitioner partners from Techbridge presented at) the FabLearn Conference, September 26-27, at Stanford University. Also at FabLearn, three practitioners and a researcher led a workshop on equity and Tinkering. Again, the FabLearn conference is notable for the opportunity for researchers and practitioners to write and present on the same topics together. Researchers from Exploratorium, with Bill Penuel from CU Boulder, published a report about RPPs in October of 2015 through the Center for Advancement of Informal Science Education (CAISE) (<http://www.informalscience.org/enriching-and-expanding-possibilities-research-practice-partnerships-informal-science>). On November 19, a practitioner-researcher partnership from Techbridge participated in an RPP webinar organized by CU Boulder.

A CTAN report and video were released in spring 2016. In April, researchers from the Exploratorium partnered with Bill Penuel to present a poster on equity and RPPs at the annual meeting of AERA in Washington DC. Bart Evans (a CSW practitioner who went on to open a new CSW site in Salinas) also attended this AERA conference as one of the RPC’s practitioner fellows. Bill Penuel and Jean Ryoo hosted him and three other practitioners at the conference, where Evans described the CTAN RPP work during a poster session on equity in RPPs.

Several dissemination efforts of the CTAN work culminated in 2016:

- 1) CTAN research report was published on the RPC website (<http://researchandpractice.org/resource/stem-making-in-afterschool/>).
- 2) Linda Kekelis (former CEO of Techbridge) and Jean Ryoo (researcher, Exploratorium) co-wrote a blog on equity in making for the National Week of Making on *Corwin Connect* (<http://corwin-connect.com/2016/06/national-making-week-support-youth-every-community/>).
- 3) CTAN won the “presenter’s choice award” on the NSF STEM video hall in May 2016 (<http://stemforall2016.videohall.com/presentations/678>).
- 4) CTAN also published an RPP card game on the RPC website in June 2016 that was first developed through the equity in RPP Inquiry group meeting that took place at the Exploratorium in May 2015 (<http://researchandpractice.org/resource/hey-partner-card-game/>).
- 5) The CTAN program profile appeared on the Afterschool Alliance website in June 2016 ([http://afterschoolalliance.org/STEMprofiles.cfm?idPage=5CB0F1E4-BB94-4572-A9074BCAB2D17E80&CNT\\_ID=STRY90006427](http://afterschoolalliance.org/STEMprofiles.cfm?idPage=5CB0F1E4-BB94-4572-A9074BCAB2D17E80&CNT_ID=STRY90006427)).



## II. THE CONCEPTION, INITIATION, ENACTMENT, AND EVOLUTION OF THE RESEARCH + PRACTICE PARTNERSHIP

### Conception and Initiation

The California Tinkering Afterschool Network RPP built and expanded on a professional development network organized by the Exploratorium with the intent to investigate and improve equity in STEM-Rich afterschool and Tinkering settings. Therefore, the CTAN partners had previous experience working with one another to address shared goals and common interests. The formation of the CTAN research-practice partnership under the auspices of the RPC was largely the result of work by Bronwyn Bevan from the Exploratorium. Bridging research and practice has long been an interest of Bevan's and she has integrated this goal into several projects she has led over time. The funding provided by the Collaboratory allowed the network to bring on additional researchers and continue their attempts to shorten the timeline between data gathering, analysis, and sharing.

Also, importantly, "learning across settings" is one of four strands comprising the Collaboratory work, and much of the focus of CTAN was on how Tinkering could be organized to leverage intellectual and cultural resources students were developing in home, community, and school settings to deepen their learning in afterschool settings. One project leader invoked the emphasis on learning across settings in her description of CTAN's approach to Tinkering:

*The ways in which we talk about cross-setting learning and STEM-Rich Tinkering in afterschool are more connected than you would think. Tinkering is this hybrid space where kids can bring ideas from multiple sources of knowledge—things they are learning in school and things they are learning at home and various languages, various cultural practices, etc. Tinkering is a certain kind of space where kids can build on their ideas and connect them to things that are valued in STEM practices. Our argument is really that Tinkering is a wonderful place to think about the whole kid and their access to rich thinking connected to STEM.*

A foundational principle of the CTAN work was to identify and disseminate practices and strategies that promote equity and serve low-income, under-represented youth. This goal in turn guided the selection of the partners (based on their own desires to being involved in the work,) the specific research questions, and the actual work and activities the partners would engage in.

While CTAN participants reported having positive working relationships previously as a professional development network in 2012, several commented that due to the RPC's intense focus on developing research-practice partnerships, the collaborations have dramatically deepened since 2014, in that there is even more trust, ownership, involvement, and common work among researchers and practitioners now. A practitioner at one of the partner sites said:

*The first time we did CTAN, I would say, 'oh it is a project of the Exploratorium, and it is where groups that do Tinkering are meeting occasionally for professional development and sharing about it'. Now when I talk about the Tinkering network [CTAN], I say, 'we are collaborating with the Exploratorium on a research project that is going to build a library of observations and research about what Tinkering is, and what the learning is that is happening when we do it'. That is a very different description.*

What was done to realize the development of this collaborative partnership? This case describes some of the routines and strategies that the researchers and practitioners have used to nurture their partnership, but it is first worth noting the initial assumptions about and conceptualizations of the CTAN work that partner leaders came with. We will also show how this RPP effectively integrated research perspectives into practice and how practice informed research, and we will share the results in practice, for staff and for youth, of the RPP. The RPC maintains a set of conjectures arguing that the results of RPPs will be more relevant and sustainable due to the collaborative and integrated way in which they are developed.

In our interviews, we heard a range of motivations and purposes for joining the work of CTAN—nearly all of which had at their core a desire to identify best practices to inform the field; to make research more practical, useful, and accessible for practitioners through close collaboration and more immediate analysis; and to value the contributions of both researchers and practitioners. Partners originally signed on because they wanted to inform the broader Tinkering and afterschool fields. The value of having multiple sites in the network is that they could learn more about Tinkering in a range of contexts, and provide insights to inform scale-up in other settings. CTAN was also determined to inform initiatives of the California Department of Education, National Research Council, 21<sup>st</sup> Century Community Learning Centers, family foundations, and afterschool networks as they focused additional attention on the potential of STEM-Rich Tinkering in low-income, underserved communities. In addition, interviewees across the board reported valuing the distinct and complementary contributions of both researchers and practitioners. One researcher said:

*We are really trying to figure out how can researchers bring their expertise in terms of the literature that they read or the research that they have done in the past—and how can practitioners bring their expertise in terms of the daily experience in their different spaces—and share the knowledge in a way that is accessible to both sides, of both worlds, and develop a new understanding of the work.*

The designation as an RPC research-practice partnership project further stimulated researchers and practitioners to deepen and expand their respective practices, create their own hybrid practice, and add value to, learn from, and broaden the reach of their efforts. The RPC's support in creating “hybrid spaces,” in which researchers and practitioners collaborate, allowed the members of CTAN to accomplish new ways of working together that help the network learn and improve itself, to deepen and expand members' practices, as well as produce knowledge that is useful to others.

Very early on in the process, partners also recognized that in addition to sharing some core interests, they had diverse perspectives and, therefore, took steps to surface and discuss those varied perspectives through Value Mapping (this process will be discussed later).

## **Enactment and Evolution of the RPP**

Several stances, routines, and processes have been key to establishing trust among researchers and practitioners in CTAN. When the partners initially came together as a professional development network, they focused on getting to know one another and sharing (through discussion and video) their practices in different settings. At this stage, the network was primarily a practitioner-centered network. The network's designation as an RPC research-practice partnership bolstered the research

component of the work. One practitioner described her understanding of the evolution of the CTAN work from a professional development network to a research-practice partnership of the RPC:

*In the first year, when we first started coming together, we were talking about how we did Tinkering and how we evaluated it, and we shared videos. Each one of us does Tinkering in a different way, and so we shared different elements of how we use it or what is special about us. Initially we focused on just the work within our groups but now with it being part of this big Research + Practice Collaboratory, we are kind of a test bed to help inform research... So we are a kind of a laboratory.*

The work of CTAN as an RPC research-practice partnership began in January 2014 with a three-month planning period to discuss research questions, design data collection plans, and routines for synthesizing data. This planning was a collective effort across the network, involving both researchers and practitioners at different levels, and, as such, was new to CTAN. It was during this planning phase, in February 2014, that CTAN held its kick-off meeting and participants engaged in a Value Mapping activity that would lay the groundwork for building their rapport, their working relationships, and their research agenda. One leader from each partner site was present and participated in the Value Mapping exercise, which served to surface and recognize different values that the members of the CTAN community brought to the work.

The Value Mapping exercise was designed to intentionally and explicitly recognize that educators and researchers might operate within different value systems and practices, and have different languages and experiences. It was seen as a means to avoid tacitly adopting the values of only the researchers. Value Mapping was described in a March 2015 CTAN report, *STEM Learning Professional Development Needs and Strategies*, which resulted from a January 2015 Inquiry Group meeting at the Exploratorium:

*Researchers and practitioners embarking on a shared inquiry answer key questions to surface the insights and values that guide their work. Ideas are written up on chart paper, discussed and clarified, and then grouped into clusters to identify the key leading sets of values, priorities, and goals for participants. The value map serves as a document of record that can guide research questions, codes, and analysis.*

To begin the Value Mapping activity, the group named the concerns and interests that had brought them together to begin with. Then, each person shared why these concerns and interests were important to him or her, both personally and professionally. The group took the initial research questions for CTAN and identified related sub-questions, which each partner could address in a particular way. The group was given time to process the questions and think about their responses before writing them on poster paper. A discussion followed, during which all were welcome to share their answers and ideas. To account for individuals who may not have felt comfortable sharing their thoughts in a whole group setting, everyone was given private time to write again. A gallery-walk then allowed each person (anonymously, if preferred) to identify which three ideas they thought were most important. Finally, the group sorted ideas into themes. Later, these themes would be useful to refining the CTAN conjectures and data codes, but at this early stage, the Value Mapping process was important as a process that welcomed and honored the perspectives of all partners.

Value Mapping helped the CTAN researchers and practitioners (including leaders, directors, and staff) hone in on problems of practice and directions for the research, without having the questions solely

defined by the researchers. Just as important, the Value Mapping activity is representative of a view held by the partners: A stance that practitioners’ as well as researchers’ experiences and perspectives are valuable. Two years after the activity, one practitioner reflected on the importance of it. In response to the question, “Have your perspectives or assumptions about research changed or evolved as a result of this collaboration?” the practitioner said:

*The work that we did upfront with the Value Mapping and really setting the research agenda together, rather than having that be something that was just laid out in advance by whoever applied for the grant or whatever... doing that really collaborative co-design was new for me in research, and maybe for my organization as well.*

While CTAN began with research questions that had been stated in the proposal, the Network partners acknowledged that these questions were fairly big and broad. Through the value-mapping activity, they honed the questions further. One researcher said:

*We had the big questions and then we did the value mapping activity, which really helped us. We started with the research questions from the grant, so there were three buckets. We took those and wanted to get more specificity and get practitioners’ ideas into those research questions: ‘What do you value about learning in Tinkering, what do you value about facilitation and Tinkering, what do you value about professional development, and how do you sustain a program? What are your values about that?’ That gave us a way to start thinking about codes, and thinking about things that we could look at on site that researchers and practitioners both valued. The value mapping provided a place for us to really ground the questions.*

The initial conception and enactment of the CTAN RPP created a space for the partners to explore ideas and questions. The actual physical map that resulted from the Value Mapping has continued to serve as a touchstone for CTAN’s inquiry, research questions, coding, and data analysis.

### III. THE INQUIRY OF COMMON INTEREST— ITS DESIGNATION AND EVOLUTION

In literature on design-based research (DBR) and design-based implementation research (DBIR) projects, considerable attention is given to the focus of the work and how that focus is negotiated and defined (Penuel, et al., 2011, Coburn, et al., 2013). In fact, an essential challenge of research-practice partnerships is to focus on “persistent problems of practice” that are truly grounded in what is relevant to practitioners. The persistent over-arching problem of practice that CTAN addressed was described in the December 2013 document, the *CA Local Laboratory Overview* as:

*Network participants are interested in scaling up Tinkering in their afterschool programs and in supporting the field and the State Department of Education in ways that are STEM-Rich and pedagogically inclusive. How can high-quality STEM-Rich Tinkering be designed and implemented, at scale, to expand young people’s access to and participation in STEM learning in afterschool programs, particularly in high-poverty/low-income communities?*

As described earlier, the members of CTAN had a previous shared interest and worked in a particular problem space—in short, to identify and share best practices for facilitating Tinkering activities to

promote equity. Prior to Collaboratory funding, CTAN had identified three questions that the group was wrestling with. These questions were written in the RPC proposal as: 1) What does high-quality STEM-Rich Tinkering look like? 2) What forms of professional development and support are needed by program staff implementing STEM-Rich Tinkering in low-income communities? 3) How can STEM-Rich Tinkering be designed to integrate into existing programs and curricula? Over time, following the DBIR process and through formal (i.e. meetings) and informal exchanges, the researchers and practitioners increased their awareness of each other's interests. The collective nature of the research is one aspect of the added value for CTAN as an RPP. While CTAN began with research questions, all of the stakeholders in the local laboratory have helped to refine the subtlety and nurture the maturity of the *means* by which to address these research questions.

Partners describe the shifts in understanding of and approach to the research questions as a result of emerging interests and discussions about goals and challenges related to issues of equity. A researcher shared her perspective on the continuing refinement of research questions as a result of researchers and practitioners working together:

*So you have overall research questions, but you discover things along the way that become interesting. So definitely there are new sub-questions coming out of iterative analysis and conversation with partners.*

As researchers and practitioners worked in local contexts, designed programs together, and discussed their work, their own researcher-practitioner dynamic influenced the inquiry as well. One practitioner described beginning their interactions with something that either the researcher or the practitioner has seen, wondered about, and is excited about. From there, the refinement of research questions was an “ongoing reflective negotiation.”

Several researchers and practitioners we spoke with recognized a strong need to advance the research such that it would be responsive and relevant to the local contexts, while also meeting the goals of the larger CTAN group and RPC. For example, one researcher said:

*As we were making our way into these complicated afterschool programs, it was sort of a mixture of making sure that we were staying true to the larger project, and making sure that we were staying true to the local context... it was a negotiation between those two things.*

In an effort to balance the larger CTAN project goals with the local contexts, the CTAN community decided that alongside the core research questions that the network agreed upon as a group, there would be a few key questions for each local site.

The researchers' observation of practice generated more specific foci for work in a particular problem area. This transparency between researchers and practitioners, and the collaborative nature of the research activity (including honing areas of focus, questions, data collection strategies, data analysis procedures, etc.) was a critical element of their interaction and work. The overall goal remained the same; the research questions did not change per se but the approach became more nuanced and sophisticated. As the project director said:

*We are trying to describe/understand what high-quality, equity-oriented, STEM-Rich Tinkering looks like, what pedagogy supporting this looks like, and what professional development supports*



*are necessary for educators trying to engage youth in STEM-Rich Tinkering. The approach to these questions has become more nuanced as research learns from practice and practitioners give input on research.*

As the research learned from practice, and practitioners provided input on research, the focus and questions actually shifted to:

- What does equity-oriented Tinkering look like?
- How is equity-oriented Tinkering facilitated?
- What kinds of Professional Development are needed to support equity-oriented Tinkering?

This shift resulted from program leaders wanting to help their program staff do good work, with the support of researchers. The interest moved toward what professional development is needed to support equity-oriented STEM-Rich Tinkering.

## IV. THE RELATIONSHIPS AND INTERACTIONS BETWEEN RESEARCHERS AND PRACTITIONERS

It stands to reason that to provide for ongoing access to one another's practices and values, and ongoing negotiation of the work, there needs to be deep trust among researchers and practitioners. CTAN practitioners and researchers all mentioned this trust, respect, mutuality, transparency, and communication as important components of their relationships and for deciding the content and direction of their common inquiry. These components helped to ameliorate disruptive power dynamics that might have played a role in more traditional research and practice relationships. In the case of CTAN, that trust was established early among the network as a whole as well as gradually through the RPP's work at individual sites.

In this section we describe some deliberate mechanisms and strategies used to facilitate the collaboration as well as how CTAN developed a shared language and produced original analyses.

### **Shared interests, values, and mutual respect**

As described earlier, CTAN partners came together initially around an issue that mattered to them: better understanding Tinkering and how to bring Tinkering into afterschool settings. Therefore, at the very least, the partners began their work with a shared interest and hoped to have the perspectives and experiences of additional partners to draw upon. This shared interest in and caring about a common problem set the foundation for the RPP. One researcher said:

*So often you hear teachers or others who are working with researchers say, 'oh yeah this researcher is coming to observe but they don't really get it'. Understanding that the researcher and the practitioner are actually looking for a problem that you both care about really sets the groundwork for the rest of the project. That seems like a really important first step that I learned from this project.*

Also inherent in the work was a shared interest in bringing research and practice closer together—for researchers to do something of practical use for practitioners and for practitioners to engage in the process of research (as opposed to simply consume it.) One researcher said:

*We are really cognizant that often times the research doesn't help the communities that are researched. We are interested in small ways that we can do short cycles of sharing back and learning from each other, in order to actually inform practice and just help out. It is not just about the research, it is also about building relationships.*

In some traditional research projects, the researcher might be positioned as the superior expert, while the practitioner is positioned as the inferior subject of the research. In an ideal RPP, the partners respect one another's distinct and complementary experience and expertise. When asked to describe how she worked with her partner, a CTAN researcher described mutual respect:

*We have a very human-to-human interaction where we take each other's expertise and ideas seriously... I guess one value we share is transparency, and so being able to share notes, share thinking, touch base on a regular basis is important.*

This mutual respect led to a high level of mutual engagement in the work. A CTAN practitioner partner who had worked with researchers in the past was surprised by the extent to which the researchers made room for the practitioners' goals, voices, and perspectives:

*I was not expecting to be collaborating at the level that we are collaborating, and the lead on that has come from the research team. The integrity of the collaborative model and the commitment to it have come from them and I have been kind of passive... passive in that the researchers are really guiding the tone of the interaction, but I feel like they have shown us new ways that a partnership can go, and it has surprised me often.*

### **Researchers' role in setting the tone for the collaboration**

As noted above, CTAN researchers treated practitioners at all levels (program directors, leaders, facilitators, etc.) politely and courteously. Their demeanor was humble and respectful, and they were responsive to practitioners' needs and constraints. A practitioner described how her partner researcher entered their initial interactions with great sensitivity:

*In the beginning she would ask, 'Can I observe this?' and ask for consent for every part. Even though I said, 'You can do whatever you want. You can observe anything you want,' she is still very conscious of getting my verbal consent every time she is there. It has moved on to, 'Can I record this? Can I videotape this? Can I take a picture?' Our relationship is built on respect, and she has been very respectful of me and the participants and our interactions.*

Another practitioner described her researcher partner's approach as very deferential:

*It is a sort of scrupulousness she has about not being an expert. I think that in order to be able to be a researcher in these kinds of contexts and not alienate people, you do have to be really scrupulous about how you present because the fact of privilege, and the fact of differences in education, and the fact of the basic power dynamic is there.*

Indeed, throughout interviews, both researchers and practitioners took a stance that it is incumbent upon the researcher in an RPP to make sure the relationship is truly collaborative, since the researcher is traditionally considered the dominant partner and the stranger in the practitioner's world. One practitioner said:

*The researcher is the stranger and I think the burden is on the stranger to promote trust, coming into a close-knit community. The burden is on the stranger—it just is. I have facilitated opportunities for the researcher to build that trust with people but you can do that to the best of your ability and a researcher can still just blow it in the first sentence that they speak or the way they listen to people or don't listen to people.*

While commenting on the RPC conjecture that it is important to take explicit measures to develop trust and mutuality, another practitioner said:

*Absolutely. That conjecture doesn't even put enough emphasis on it, just how explicit those measures have to be. I would even say something like, 'explicit measures to build trust have to be built into every aspect of every interaction and it has to be constantly on the mind of the researchers' because they are coming in with a loaded power dynamic.*

Researchers described being very intentional and consistent in their reflection on their own interactions with practitioners, asking themselves whether they might have made faulty assumptions or said anything to make a practitioner feel uncomfortable or disrespected.

### **Norms, strategies, routines, and tools**

When describing how CTAN researchers and practitioners developed and maintained trusting relationships with one another, partners invariably described the strategies and routines they designed as a means for reinforcing the norms of this RPP. These strategies and routines, which included the creation of tools, helped to create a new dynamic among researchers and practitioners where information was shared readily and frequently, and the work was focused on issues that matter to both parties.

A norm that was critical for maintaining productive relationships between researchers and practitioners involved transparency and frequent and consistent communication. Discussing values and goals early and often helped practitioners feel comfortable sharing what they needed and were interested in, while researchers were transparent about their work. In fact, transparency throughout the project—from the very first phone calls—allowed for open sharing among researchers and practitioners in a safe environment. Practitioners appreciated the fact that CTAN researchers shared, even before their first site visits, the indicators that they were interested in looking for at the site and asked for practitioners' feedback. The researchers said, "This is what I am going to be looking for at your site... Do you think this is interesting and did we miss anything?" Practitioners valued having this initial opportunity to provide input into the research.

The strategies and routines that partners mentioned most often included researchers being present at the site on a regular and consistent basis to build relationships, researchers sharing field notes openly and frequently, and researchers creating videos and programs (including afterschool activities

and professional development workshops) that they then shared with practitioners, including line staff. A practitioner described what was valuable about the researcher sharing video and field notes:

*By introducing video of what she sees as stellar, really great facilitation moments, and getting staff to talk about it (e.g.) ‘but we are not seeing these moments all of the time and why aren’t we doing this all of the time?’ it is like finding weaknesses in their own work and wanting to improve it, which I think is really exciting. There is something that needs to be pointed out about the fact that [the researcher] is able to do that and have it not feel invasive to people because she has spent so much time just hanging out with us and not judging, but learning. She has really been such a learner and she has presented as a learner so conscientiously... For someone to be able to come and interact in a way that gets people to think constructively about their own work, I think has been really impressive to me. Some people are super-suspicious of outsiders.*

One researcher described these routines as “working routines” for continuing to maintain trust. Others noted that it was a necessary skill on the part of the researcher to have a good sense of how much and how often to share relevant information through these routines, simply because practitioners are so busy: “there is enough detail and enough context and, at the same time, people aren’t reading 50 pages of notes.” By inviting a practitioner to discuss raw field notes, the researcher invited her into the process of data analysis and further refining research questions.

As described earlier, some researchers helped to plan and implement professional development workshops as well as afterschool activities. When asked how it was decided that these routines made sense, this practitioner’s response illustrated the organic, emergent, and responsive nature of the researcher-practitioner relationship:

*In terms of the field notes, I would never have asked to see them because I kind of thought that that was off limits, but [the researcher] offered to show them and started sharing them with us right away. And then her helping with planning the PD actually started because she happened to be visiting [our site] on the day that we were planning one of our big professional developments and [the researcher’s] contribution to that conversation was so valuable that we started doing it more often. It was kind of an accident.*

It is important to note that while informal educators and practitioners are often very reflective in their work, they do not always have time to collect data in a systematic or even consistent manner. Having a trusting relationship with a researcher allowed CTAN practitioners to focus on the matter at hand, while the researcher collected data to discuss with the practitioner—and the two of them applied and adapted theory where it was relevant. A practitioner described this as a great help:

*What I really love about working with [the researcher] is that she says, ‘you don’t have to write anything, I will write it and I will just talk about it with you’. She is saying, ‘obviously your time is important and obviously you have this job that you have to do but because your ideas are so great, I really want to incorporate them into a piece of written work that I can produce, which is part of my job’. It is a way of presenting. It is another detail of how she is presenting her role as one of service essentially... service and learning.*

Practitioners also mentioned informal routines, such as having researchers socialize with staff as well as program leaders, as being important for maintaining trust.

Over time, these strategies and routines became more or less formalized and led to the creation of tools. One researcher made distinctions between the routines of traditional forms of research she had been involved with and the work of CTAN. She described how, through the process of discussing data in order to create tools, CTAN researchers and practitioners were brought together into data analysis to discuss what matters in practice and to communicate that to other practitioners:

*The creation of tools has been a really iterative process... that also has been a kind of routine that hasn't existed in other research projects that I have been on, and it is a form of analysis. It is people making sense together and negotiating what is important here – 'why is this equity-oriented?' Or 'why are these little moves within facilitation something that we want to express and talk more about with other facilitators or share more broadly?' Those conversations take place to create tools that will help practitioners. They are a kind of research analysis. Not an interview, not an observation, but somewhere in-between.*

One such tool that resulted from this collaborative data analysis is a framework for building equity in RPPs (<http://researchandpractice.org/resource/building-equity/>) that researchers from the Exploratorium and practitioners from Techbridge developed together. This framework describes why equity is important in an RPP and it provides some pointers for how to establish effective RPPs. While it is beyond the scope of this study, understanding how the tools that CTAN developed are used in other contexts will be important to learn about in the future.

### **Developing a shared language**

Through several different activities and over time, the CTAN group designed new ways to represent and conceptualize their thinking and their work (such as the Value Mapping activity) and developed a shared language. These common activities, representations, and terms created references that would be understood between the researcher and practitioner communities. Practitioners were able to share the language and currency of their local contexts, while researchers were able to share the language and currency of learning theory, and together they developed a language that should make sense to communities beyond this RPP. A researcher explained how the language that was developed and disseminated through CTAN might benefit others:

*[The practitioner] was really interested in working with researchers because she felt like there was a lot of really cool stuff going on in her site and she could describe it to people in conversations and to the facilitators and to funders... but she knew that there were deep learning theories going on there as well and said she didn't have the language to describe it prior to this work.*

Similarly, a practitioner explained why she thought it was important to have a shared language:

*It is helpful to the field because it means that we can communicate more effectively, and it is helpful to us because it makes us more coherent and we present stronger that way. I think if we want this work to affect practice, we have to get to the point where staff are all using that language and those constructs.*

Another researcher commented on how the common language, representations, and references exemplify the CTAN research-practice partnership. She used the term “facilitation muscles” as an example of a term that grew out of and became a focus of the work within CTAN:



*I think a lot of the tool creation that we are doing is an obvious example of a common representation. Even the term ‘facilitation muscles’... that was created by a practitioner during our September meeting—we were trying to get to this idea of something that facilitators have to practice and when they practice, they can get better and someone said ‘it is like a muscle.’ That language has traveled with us and even the representation and the tool itself is sort of a nice example of our shared work.*

The language and representations that CTAN partners co-developed and refined over time ultimately evolved into the tools we describe elsewhere in this case, in addition to collaborative papers and conference presentations.

### **Producing original analyses, writing, and presenting**

The researchers and practitioners in CTAN have written papers, proposals, and research briefs together, and they have collaboratively planned and presented at conferences. This joint activity continues to benefit all the CTAN partners, in that they gain more experience communicating about and disseminating their work, they reach new audiences, and they elevate the profile of their respective institutions and the Network itself. One example is the presentation titled *Tinkering with “Failure”: Equity, Learning, and the Iterative Design Process*, which researchers from the Exploratorium and practitioners from Techbridge organized and presented at the FabLearn Conference at Stanford University in September 2015. The Exploratorium has created several research briefs—each is a two-page overview or synopsis of research literature or literature reviews with titles such as “An Overview of Learning through Making and Tinkering,” “Having Fun and Learning through Tinkering,” and “How Making Projects can Promote Deep Learning.” Practitioners reported that they felt the researchers did the “heavy lifting” on writing papers, and they were appreciative that their voice was still included and the researchers made room for them to be involved at all stages, even if the practitioners’ schedules did not always allow for it.

## **V. MULTIPLE BENEFITS OF THE CTAN RPP**

Through observations, interviews, and document analysis, we have learned of multiple benefits of the CTAN partnership to those directly involved in the work as well as to others in the fields represented by the partnership. This section describes the benefits of the work of the RPP to individuals and organizations.

### **Benefits to individuals**

While many practitioners are active consumers of research, they seldom have a chance to engage in systematic inquiry of their own practice. While certainly reflective and thoughtful, they have scant time to collect data in a consistent, intentional way, much less time to sit with that data, analyze it, and reflect on what it means for their own and others’ practice. With a research partner whose job is to do these things, the practitioner can not only focus on their work but also engage in it, reflect on it in new and different ways, and communicate it to different audiences. CTAN has been **a means for practitioners to receive additional layers of feedback on their work and has created a space for them to make meaning of it with their colleagues**. CTAN has **allowed practitioners to contribute to**

**the research enterprise in other ways** as well, as they have co-authored and co-presented findings from their RPP. One practitioner said:

*Having the opportunity to work on papers and present at conferences and do webinars... those are things that I should be doing as part of my work that I don't always get the chance to... I just don't have enough time. I especially wouldn't have any chance to work on a peer-reviewed paper. So that piece of the work for me as a professional has been incredibly valuable.*

The project director of the CSW Network described how the RPP benefitted staff facilitators by **bringing in new perspectives on the value and impact of their own work** and their potential contribution to research:

*The way the researcher shared the research and her process with the staff helped them better understand the greater context of their work, and enhance their awareness of the depth and intricacies of the learning happening in their programs. The result was them being able to identify and deconstruct the reasoning for a specific facilitation decision or teaching technique, etc.*

Individual researchers had the opportunity to be involved in the actual design of programs and activities, not just the observation and analysis. Furthermore, researchers said that their experience in CTAN **shaped their perspective of the possibilities of RPPs more generally, and that it will continue to influence their approach to conducting research in future projects**. One researcher said:

*Working with folks in CTAN has impacted the way I think about all my future work and collaborations. I can't imagine ever conducting research that isn't RPP in the future. Why would I ever do research that doesn't make an effort to equally involve educators, practitioners, etc. in the research that I do? It just doesn't make sense to do research work without collaborating with practitioners, or to create resources from that work that fail to take into account the needs and interests of educators, administrators, etc.*

Both researchers and practitioners described having a **better understanding of the national landscape of Making and Tinkering, and the afterschool context** through the collaboration inherent in CTAN and the RPC. They report having learned a great deal from others across the Network and the Collaboratory. The Project Director of CTAN at the Exploratorium said:

*Through the Collaboratory, I have gained new insight into what it means to create and sustain an RPP that constantly works on developing equitable and supportive relationships across researcher and practitioner partners. I have learned this not only by jumping into leading CTAN, but also by learning from the work of other Collaboratory sites. It has been helpful for thinking about RPPs in the larger context of the nation and public policy.*

## **Benefits to partner organizations**

The opportunities that the CTAN RPP generated for researchers and practitioners to engage together in design and research created benefits to their respective organizations as well. One practitioner commented on the value of having an external party provide **a more global perspective on localized practice and its relative importance**:

*We have really benefited from the researcher coming in as an outside observer to our program and being able to reflect back for us what she was seeing in programs... to have somebody else saying,*

*‘oh here is where I see evidence of NGSS skills and practices,’ for example, or ‘this is an example of the different varieties of ways that facilitation happens in your program’ has been so valuable.*

Conversations that began between researcher-practitioner pairs about promoting equity and advancing practice usually extended beyond the pair to include directors, facilitators, and line staff—across multiple levels—and this **generated organizational capacity for engaging in inquiry and improving programming** that is likely to live on in the organization beyond the tenure of CTAN. The former Executive Director of Techbridge described how her organization benefitted from the RPP:

*I knew this could be an opportunity for Techbridge to contribute to educational research and benefit from the expertise of researchers. I was right. It was an amazing opportunity to have a researcher embedded in our program. The insights and questions from [the researcher], who made weekly visits, helped us reflect on our practices and shed light on how to make Making experiences more accessible to the girls we work with. It offered our staff an opportunity to deeply reflect on their work and also gain insights into the experiences of our girls.*

The equity and Tinkering focus of CTAN prompted organizations to **rethink their approach to programs that once fell outside of the Tinkering umbrella**, such that now their other programs incorporate more equity-oriented facilitation and re-framing of “failure” as an essential part of the engineering iteration process. One practitioner said:

*The shift is maybe a subtle one but we are even more focused on Tinkering as the approach that we take with all of our activities than we were before... Participating in CTAN has—both for me and for the program coordinators who were directly involved, and then also through the trickle down of the professional development that we do—caused us to take on that Tinkering ethos and mindset, and it is the way that we approach almost all of the work that we do with kids now... Being part of CTAN has helped to push us in that direction and also helps me be more mindful about how we do professional development around it.*

The CTAN RPP **created the time and space for practitioners to really explore issues they had been concerned about** and made observations about, but hadn’t been able to wrestle with and focus on. One partner organization in CTAN recently hired a research and evaluation coordinator. A director from that organization said:

*I definitely think seeing the benefits of research in the program made us really more excited about hiring a research coordinator.*

Participating in CTAN also lent a certain **legitimacy** to the work of partner organizations, particularly because of the reputation of the Exploratorium and its research capacity, and funding from the National Science Foundation. Several practitioners stated that the RPP provided them with **an increased ability to communicate about the work of their organizations**, along with additional venues and audiences to reach—all of which **raised the profile** of the organization. One Education Director said:

*Working with CTAN has been an exciting venue to geek out with and learn from others doing similar, great work. The final products feature a lot of what we are doing in our own programs, which is great because it validates our work (very important for out-of-school, informal programs), and also spreads*

*the message of what is possible. Had we not been part of CTAN, we would be lacking a certain legitimacy and would also be missing an important avenue to get our ideas out into the field. It has also been a form of professional development for workshop staff, helping them to better understand and describe what they are doing and why.*

Similarly, the Project Director of CTAN described **new opportunities for organizations to publicize and validate their work:**

*For the CSW Network, this research adds credibility when we advocate on behalf of CSWs and the CSW model, and also excites us and validates the work we are supporting, which is great. Part of our mission is spreading the techniques, design, and philosophy of what we do and why, which I think was well captured by the collaborative research work as part of CTAN.*

### **Benefits beyond the immediate research-practice partnership**

Beyond influencing the researchers and practitioners directly involved, and their host organizations, the work of the CTAN RPP has and will continue to influence the field of informal science education, the Tinkering-Making community, educators with whom these organizations work, and youth participants with whom they work. CTAN figured prominently in a Center for the Advancement of Informal Science Education forum on InformalScience.org that focused on design-based research and design-based implementation research in informal science education settings. The forum involved 23 active participants and was viewed by over 300 members of the website. CTAN served as an important example of the benefits of long-term relationships, and tools developed through this partnership were shared with the broader informal science education field.

The CTAN RPP has resulted in approaches and stances toward research-practice partnerships as well as tangible products that have been and will continue to be of use to others in the fields of informal science education and afterschool learning and those interested in RPPs. For example, many of the tools have been included in the RPC RPP Toolkit. Leaders from the CTAN partner organizations frequently mentioned their positive experiences making conference presentations and meeting with others in the field who are interested or involved in RPPs and the resources CTAN provides.

Several CTAN members described how their experience in CTAN changed their ideas about what is possible in terms of bringing researchers into the practitioner space, and the potential value of doing so. This experience is likely to influence how researchers and practitioners interact with research in the future. One practitioner said:

*Having the researcher really embedded in our work expanded our idea of what is possible in terms of how you can interact with researchers... We are [our organization is] often thinking about data collection from an evaluation perspective, as opposed to the kind of really in-depth embedded research that [the researcher] was doing. That has changed our perception of the value... Now it seems like such a luxury... What an amazing thing to have somebody who is able to come into your program, week after week, and talk with you and talk with the people leading the program and make these observations. I think it felt like a rare and special thing.*

## VI. THE CASE AS ILLUMINATIVE OF DESIGN-BASED RESEARCH + PRACTICE PARTNERSHIPS

The case of the California Tinkering Afterschool Network illuminates an RPP in the informal or out-of-school domain, which had Tinkering and equity as its concentration. The researchers and practitioners of CTAN negotiated problems of practice on which to focus, allowing problems to emerge from local practice while still ensuring they were consistent with the larger goals and guiding questions of the Network. CTAN was iterative in its design processes, developing strategies and routines to strengthen participants' relationships and their joint work. CTAN also considered issues of scaling-up as they provided evidence to support the implementation of high-quality STEM-Rich Tinkering experiences.

The partners' keen interest in reaching traditionally underserved audiences extended to their work together. To inform practice, they strove to make research meaningful and readily available to audiences that may not typically be invited into the research domain. The researchers assumed the role of being the "outsider" or the "other" in these partnerships (one referred to herself as the "stranger"), and they took the responsibility to maintain a respectful interaction through these new ways of working. Several researchers and practitioners alike described "manners" and "scruples" that were important for researchers to have in these contexts, and the importance of developing a rapport and simply socializing. In turn, the partnerships were deepened and strengthened through the actual doing of the work itself—the planning, facilitation, data analysis, writing, and presenting. Mutual respect grew with each step. As a result, the researchers and practitioners described working in new hybrid spaces with different routines. One practitioner said:

*[The researcher] has done a few sessions with the staff where they have critiqued themselves and thought about positive facilitation strategies. It has been kind of a revolution actually because it is causing people to question their work in a way that the culture didn't necessarily have room for before.*

When asked to reflect on the importance of CTAN another practitioner said:

*From hearing about other people doing research in the field, and going to ASTC and hearing about how other people do research, I think this partnership is something really new. It is an important model for getting real information from marginalized voices into the field. I would argue that almost all practitioners – real frontline practitioners – are marginalized voices in the field. This partnership is something new and is really valuable.*

Another added:

*The experience of co-designing a research project and having a good, close working relationship between research and practitioners is so important that everybody should be doing it.*

### Thoughts on formal versus informal RPPs

There is far less research in the informal science education field in general, compared with the formal realm, and even less in the world of Making and Tinkering, which is relatively new. Informal RPPs provide a real opportunity for solid design-based implementation research (DBIR) work in this



domain. Making and Tinkering programs are well suited for this, given their stance toward learning and their relatively innovative approaches. CTAN contributed substantially to the research knowledge base in informal science learning, RPPs, and DBIR.

Recent blog posts on Design-Based Research and Design-Based Implementation Research describe how CTAN's driving questions highlighted the subtleties of DBR and DBIR. For example, *What does effective facilitation of equity-oriented, STEM-Rich Tinkering involve?* is the kind of question that is often pursued through DBR. It focuses on design for learning in informal STEM learning environments. But the addition of the question, *How can we support educators to develop facilitation skills that sustain Tinkering in afterschool programs?* demonstrates the emphasis on implementation and capacity building that are central to DBIR. In other words, CTAN generated knowledge about learning designs and innovations to make STEM more accessible to historically marginalized youth AND knowledge about how programs and organizations can ensure such learning innovations are adopted, adapted, and sustained.

An overriding challenge of RPPs in informal education settings is the relative instability or inconsistent nature of the programs, the preparation of staff, and staff's tenure. Schools or formal education institutions are thought of as relatively stable, steeped in tradition, and often resistant to change, while informal education institutions are often considered more innovative and embracing of change. Whether true or not, these are factors to be mindful of as we learn from RPPs in both formal and informal contexts.

True Design-Based Implementation Research requires collaboration among stakeholders across various levels of the system (from facilitator-educators to program developers to directors) who influence implementation, along with consistent iterations in design. However, just what constitutes "the system" in informal education RPPs might not be as obvious as what "the system" entails in formal education. In the case of CTAN, network and organizational leaders met in the same groups as program leaders and frontline educators—a system-wide approach.

In informal contexts there is often rapid staff turnover relative to formal education contexts, and this can complicate the design, the implementation, and the research aspects of DBIR. Indeed, several of the individuals who participated in early meetings of CTAN moved on to other positions in other locations by the end of the project. The challenge for sustaining the work then is to make sure to engage enough personnel across the systems so that when one individual leaves they do not take all of the capacity for the RPP with them.

Another challenge of RPPs in informal settings is the reliance on grant-funded capacity building with short funding cycles, especially when coupled with the issue of frequent staff turnover. DBIR is highly dependent on relationships and long-term trust building. CTAN is an example of an effort that originally began with short-term grant funding and was extended with support from the Collaboratory funding, allowing for the time needed to build relationships, collaborate on a common problem of practice, and produce research, tools, and resources.

## EPILOGUE

As of February 2017, multiple developments and accomplishments have occurred since CTAN's official funding came to an end. They are worth reporting, for they exemplify the lasting benefits of this RPP. In April 2016, the CTAN group published a report summarizing the findings from their work: "Making as a Strategy for Afterschool STEM Learning: Report from the California Tinkering Afterschool Network Research- Practice Partnership" (<http://hub.mspnet.org/index.cfm/29364>). In addition, there are several articles in various stages of publication that have been co-authored by a CTAN researcher with practitioners: an article in *Afterschool Matters* (in press, spring 2017); a paper for the *Journal of the Learning Sciences* (drafted); and an article on "failure" for the *Thinking Skills and Creativity* journal. Practitioners and researchers from CTAN have also co-written blogs about RPPs and led sessions together at conferences, including AERA and the Lighthouse + Lodestar conference.

Bronwyn Bevan (now at University of Washington) and Jean Ryoo (Exploratorium) have developed a new research-practice partnership with Lighthouse Community Charter School in Oakland, California, to explore how students' informal or out-of-school time learning through Tinkering might be integrated into and leveraged during formal, in-school time. The focus is on how to design and implement equity-oriented afterschool Tinkering programs that might be integrated into the school day. This Lighthouse Community RPP work will be shaping a massive open online course (MOOC) to reach a vast audience of interested folks across many disciplines. This RPP work builds on the CTAN RPP work—they use many of the tools (e.g. Value Mapping) and briefs that were developed in CTAN.

The work in inquiry group meetings with afterschool educators has evolved into comprehensive professional development opportunities for formal, in-school educators as well. Bevan and Ryoo shared this inquiry group work at a school leadership meeting in June 2016, a schoolwide professional development day in December 2016, and a professional development meeting for educators outside of the school in December 2016. Bevan has been invited to share insights from this work in her capacity as an advisor to the California Department of Education's extended learning in STEM program.

CTAN partners continue to work together as opportunities arise and to stay in touch via periodic conference calls. This has given practitioners the advantage of having ready access to research, resources, researchers, and other forms of professional support. One participant referred to this as "having a researcher on speed dial." Inverness will not be formally studying the work described in this epilogue, however these are important examples of how, through the ongoing iterative engagement of and collaboration among researchers and practitioners, the CTAN RPP continues to generate new questions, initiatives, and collaborations after its official tenure has passed.

The previous work of CTAN and its legacy, in the form of ongoing collaborations, raises interesting points and questions for partnerships. One is, what does "long-term" mean, exactly, when thinking about an RPP? In the case of CTAN, the relationships are ongoing and the participants continue to support one another's efforts. While the project is officially over, in terms of funding, the close relationships among researchers and practitioners that were cultivated and refined through CTAN endure, suggesting that a form of an RPP still exists. "Having a researcher on speed dial" doesn't have to end for practitioners when funding is over; indeed, it can be a more practical and less daunting

solution to problems of practice than a large formal 10-year collaboration might be, for example. The persistent nature of the less formal collaboration among CTAN researchers and practitioners is a good example of one way a “long-term” relationship might work. These individuals respect and support one another as professionals, and their support is not limited to or confined by one project’s particular and specific focus.

An important issue that is highlighted by the CTAN example is that the work of RPPs can be cumulative. Each RPP can be stronger than those that came before when one carries forward the lessons learned. For example, the Lighthouse Community Charter School RPP work launched more smoothly than the CTAN work did, in large part because of what individuals learned through CTAN.

Another interesting question generated by this work relates to the importance of working across different levels in a system and having “the right people at the table.” In an informal RPP, identifying just what the “system” is can be difficult. With the addition of staff turnover and short funding cycles, maintaining continuity in the work across a system is more of a challenge. Informal education institutions are often driven by a desire to innovate and, therefore, funding in the informal domain often depends on whether an idea or project is considered new—foundations typically do not like to continue to invest in sustaining the same work over time. Individuals who participated in CTAN have asked themselves after the fact whether they had the right people at the table—whether they should have had more funders or more state administrators involved for a longer period of time.

Results from this work have been disseminated to the field through publications, Massive Open Online Courses, conferences, and other communications; therefore, the results live on and can influence future RPPs. In addition, the CTAN RPP was a very rich research-practice experience that will continue to nurture the participants who were involved and provide sparks for future collaboration. Perhaps this is the message for the field: a particular RPP may not be funded or formally sustained forever, yet the relationships that grew out of that RPP can continue forever if they are sufficiently strong. If an RPP formally exists for only a few years, there is no reason to assume the work will stop when the funding stops. Indeed, a true RPP is an effective means by which to build and then sustain capacity that matters for improving both research and practice.

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