A Framework for Examining Research Practice Partnerships for K-12 Computer Science Education

February 2022

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This material is based upon work supported by the U.S. National Science Foundation under Grant No. 1745199. 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.

Suggested Citation: *McGill, M.M., Menier, A., Sexton, S., Zarch, R., Peterfreund, A., Kargarmoakhar, M. (2022). A Framework for Examining Research Practice Partnerships for K-12 Computer Science Education. CSEdResearch.org: Peoria, IL USA. DOI: 10.13140/RG.2.2.15528.03840*

Acknowledgement: As our partners on this NSF-funded work, we acknowledge and thank the CS-forALL team for their support and discussions on this work.

PUBLISHED BY CSEDRESEARCH.ORG with encouragement and support from SageFox Consulting Group.

First printing, February 2022

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1. Introduction

Research Practice Partnerships (RPPs) have been increasingly used in K-12 education to address general problems of practice through a unique collaboration that includes various stakeholders (i.e., researchers and practitioners) committed to designing and implementing solutions. Recent examples of the types of problems that RPPs seek to address include reducing student disciplinary infractions and number of failed courses, improve student grades and attendance (Cannata et al., 2019), obtaining evidence that could inform policy and help students make decisions about their future educational and career paths (Wentworth et al., 2017), and examining and addresses issues of inequity and access to equalize status and increase student engagement (Wentworth et al., 2017).

Although the formal concept of and implementation frameworks for RPPs have evolved over the last 30 years, in the context of K-12 computing education RPPs are relatively new. In 2017, the U.S. National Science Foundation (NSF) issued a call for proposals for implementing Research Practice Partnerships (RPP) for Computer Science (CS) for All (National Science Foundation, 2020)[1]. The intent of this K-12 initiative was to foster research into and development of curricula based on mutual partnerships between researchers and practitioners and to learn from these implemented projects.

It is worth noting that this funding program is currently a large portion of the federal funding streams for researchers seeking to do pre-K-12 Computer Science Education work. Thus, much of federally-funded CS work is by necessity happening via an RPP modality. Given the relative newness of pre-K-12 computing education and computing education research, it is likely that this will have impacts on the overall trajectory of the field, the speed with which it can propose, test, and refine new ideas and approaches, as well as the nature of work around issues of equity, among others. Thus, work to analyze, understand, and compare RPPs could also provide insight into the development of the pre-K-12 computing education discipline overall.

Since 2017, 117 unique projects were borne from this initiative, yielding many new RPPs for CS in various stages of progress (see Table 1.1). Projects ranged from early elementary grades to high schools as well as pathways to post-secondary schools and sought to address such problems as:

- Challenges associated with providing every high school student high-quality, introductory CS

[1]The program synopsis reads: "This program aims to provide all U.S. students the opportunity to participate in computer science (CS) and computational thinking (CT) education in their schools at the preK-12 levels. With this solicitation, the National Science Foundation (NSF) focuses on researcher-practitioner partnerships (RPPs) that foster the research and development needed to bring CS and CT to all schools. Specifically, this solicitation aims to provide high school teachers with the preparation, professional development (PD) and ongoing support that they need to teach rigorous computer science courses; preK-8 teachers with the instructional materials and preparation they need to integrate CS and CT into their teaching; and schools and districts the resources needed to define and evaluate multi-grade pathways in CS and CT."

Awarded	Funding Amount	Number of Projects
2017	$27,588,674	34
2018	$24,952,423	37
2019	$20,111,122	26
2020	$25,324,183	54
2021	$24,842,137	49
Total	$122,818,539	200 (158 unique[2])

Table 1.1: U.S. National Science Foundation's Computer Science for All Initiative, 2017-2020.

course (Henrick et al., 2019),
- Lack of engagement and learning and student participation in computer science education, including the role of relationships with peers, staff, and other mentors, as well as whether digital micro-credentials can be used to increase engagement and learning (Denner et al., 2019),
- Lack of teacher and school capacity to implement maker activities (Fancsali et al., 2019),
- Lack of computational thinking and computer science education in middle school (Gilbert et al., 2018; Wiebe et al., 2019),
- Lack of equitable access of Advanced Placement (AP) Computer Science Principles (CSP) courses for all students (Mark et al., 2020), and
- Lack of computer science curriculum to teach students with learning differences (Wille et al., 2016).

Within these projects, RPPs have been conceptualized and implemented in various ways across computing education. Coburn et al. recognize a need for comparative studies across RPPs to better understand them (Coburn et al., 2015). Despite this, however, there are no existing frameworks to serve as a means for deconstructing these partnerships in a formal manner that would allow for consistent comparisons and analysis. To do this holistically, three frameworks are needed for analyzing and comparing:

- The partnership portion of the RPP,
- The educational context (i.e., computer science) of its implementation, and
- The output of the RPPs (e.g., contributions to their institutions and to the broader CS education research community, long-term versus short-term impacts).

In this research study, we create the first framework based on the following research questions:

1. *What would a broad framework for analyzing and comparing the partnership aspect of RPPs for primary and secondary computer science education entail?*
2. *If we investigated one component of the framework, what would we learn from its analysis?*

To explore these questions, we provide a literature review that covers the different facets of RPPs, including how they can be structured and their known benefits and challenges. Using this knowledge as well as our deep understanding of RPPs in CS, we propose a framework for RPPs that could be used for analysis. To gain an understanding of how one of the components of the framework can be used, we conducted a content analysis and analyzed the project descriptions, broader impact statements, and intellectual merit statements from a subset of the 117 funded NSF CSforAll: RPP projects. This provided insight into how this one concept can be examined and some of the other considerations that

must be made when comparing data within the other components.

This study is relevant to researchers, practitioners and other stakeholders within the CS education community who want to understand how to compare and analyze multiple RPPs or how to compare a single RPP across different years or projects. In this article, we provide a background of RPPs, followed by our proposed framework and the results of our analysis of the first component, Theory of Change. This is followed by a discussion of what we learned about the framework and its components and how they can be used to conduct comparative analyses.

2. Research Practice Partnerships

Much has been written recently about RPPs in the context of education, including their benefits and challenges. Here, we discuss central tenets of RPPs and their implementation across education.

2.1 Definition and Key Components

Though practitioners and researchers both are outcome focused and are interested in increasing academic achievement among students, the gulf between the two has often been (and is still) very wide (Wanzer, 2019). Formerly referred to as School-University Partnerships (Brookhart and Loadman, 1992; Gifford, 1986; Schlechty, Whitford, et al., 1988 40 years ago, these partnerships were established for many of the same reasons they are today–to solve the problems that arose from the deep separation of research from practice. Once the research concluded, the findings would then be disseminated to practitioners. The research was often conducted in silos and the hand-off from researcher to practitioner did not always meet the critical needs that practitioners faced or may not have adequately considered the context of their work (Hod et al., 2018; Penuel and Farrell, 2017).

Full participation by practitioners in the course of conducting research could mitigate these problems and ensure that the practitioners' voices, context, and experience are considered. Likewise, practitioners learn how to study and learn from research, building the knowledge needed for practitioners to leverage research in their decision-making within a particular context (Coburn et al., 2013; López Turley and Stevens, 2015; Penuel et al., 2015; Resnick and Kazemi, 2019; Tseng et al., 2017). Through RPPs, the gap between researchers and practitioners lessens (Boser and McDaniels, 2018). Ghiso et al. points out nuances in the formation of RPPs, noting:

> Research-practice partnerships (RPPs) call on forms of professional knowledge that may have traditionally been less visible or valued in the academy. Collaborative research teams are engaged in deeply relational intellectual and emotional labor: They have to develop methodological sensibilities and skills that are attentive to issues of power and have to negotiate social and institutional boundaries. (Ghiso et al., 2019, p. 1)

In the context of education, Coburn et al. defined RPPs as "...long-term collaborations between practitioners and researchers that are organized to investigate problems of practice and solutions for improving schools and districts" (Coburn et al., 2013, p. 48). Their intent is to "...leverage research to address persistent problems of practice" (Henrick et al., 2017, p. 1) for improving districts and schools (Coburn et al., 2013). RPPs are intentionally organized and can be focused within a single school, but typically they involve several schools, a single school district, multiple school districts and

even supporting agencies. They also can be formed across distributed networks (e.g., special education providers across a state) (Coburn and Penuel, 2016; Coburn et al., 2013).

Three basic tenets of RPPs are that they are long-term collaborations, mutualistic, and consist of efforts to build and maintain trust among their participants (Henrick et al., 2016). The long-term component of the structure and intent of RPPs is indeed paramount to their success. The long-term approach allows for the time and space needed to institute a continuous improvement paradigm (Shakman et al., 2017), including the Plan, Do, Study, Act (PDSA) cycle that needs to be continually repeated to identify promising practices and bring those practices to scale.

In addition to being collaborative, long-term, and focusing on problems of practice, by their very nature RPPs are designed to be mutualistic, to equalize the power structure between researchers and practitioners, and to elevate the concept of joint work where researchers and practitioners work collaboratively to design and implement solutions, study their impact, and act by redesigning and refining their solutions in order to increase impact (Penuel et al., 2015). The investigation of the problems and their potential solutions are co-created by both researchers and practitioners (Bevan, 2017). Trust is a key element of a successful partnership and reliance on roles and responsibilities that are established upfront help ensure that proper boundaries are set and trust is maintained. This trust is built upon the discourse around the problems which they seek to solve mutually and for similar interests (Hod et al., 2018).

RPPs also involve original analysis of data, a practice that involves the collection of data within the context of the problems being solved, within the context of the district(s) or school(s), and/or within the context of an intervention, program, or reform strategy (Coburn et al., 2013). This enables the district leaders to become familiar with the data and be able to analyze and interpret the data in a way that considers their unique district frameworks within which they operate.

2.2 Process Commonalities and Framework Implementations

2.2.1 Process Commonalities

There are similar and shared functions among different ways in which RPPs are implemented. Figure 2.1 shows the various steps of how RPPs function and the important key processes within them (Lash et al., 2019). We briefly highlight each here.

Establish an Equitable Partnership. Connolly notes that even with RPPs, "everything grows from a strong foundation" (Connolly, 2019, p. 1). Part of this is also recognizing that the ecosystem of connected academic enterprises and institutions can result in positive change that impacts youth (Connolly, 2019; Wiebe et al., 2019).

Create a Memo of Understanding. To facilitate the partnership, rules of engagement can help lay the groundwork of expectations, roles and responsibilities for the RPP (Lash et al., 2019).

Collaboratively Identify the Pressing Problems. Collaboration strengthens the RPP, demonstrates its value, and can help institutionalize the work (Connolly, 2019). It can also ensure that the right problems of practice are being addressed (Wiebe et al., 2019). Identifying and decomposing the pressing problems can be aided by the use of the Edelsons design methodology and other step wise processes that include grounding the decomposition in practice through the RPP team members' vision (such as "techquity"), by function, and in relation to the contexts to which it applies (Kalir, no date; Muñoz, 2016; Resnick and Kazemi, 2019; Thompson et al., 2019). This requires a range of perspectives and can further identify relevant stakeholders who should be included in the RPP (Resnick and Kazemi, 2019).

Include all Relevant Stakeholders. Creating the partnership should be thoughtfully based on addressing power imbalances, addressing issues of trust, sharing of information, and strong communication as

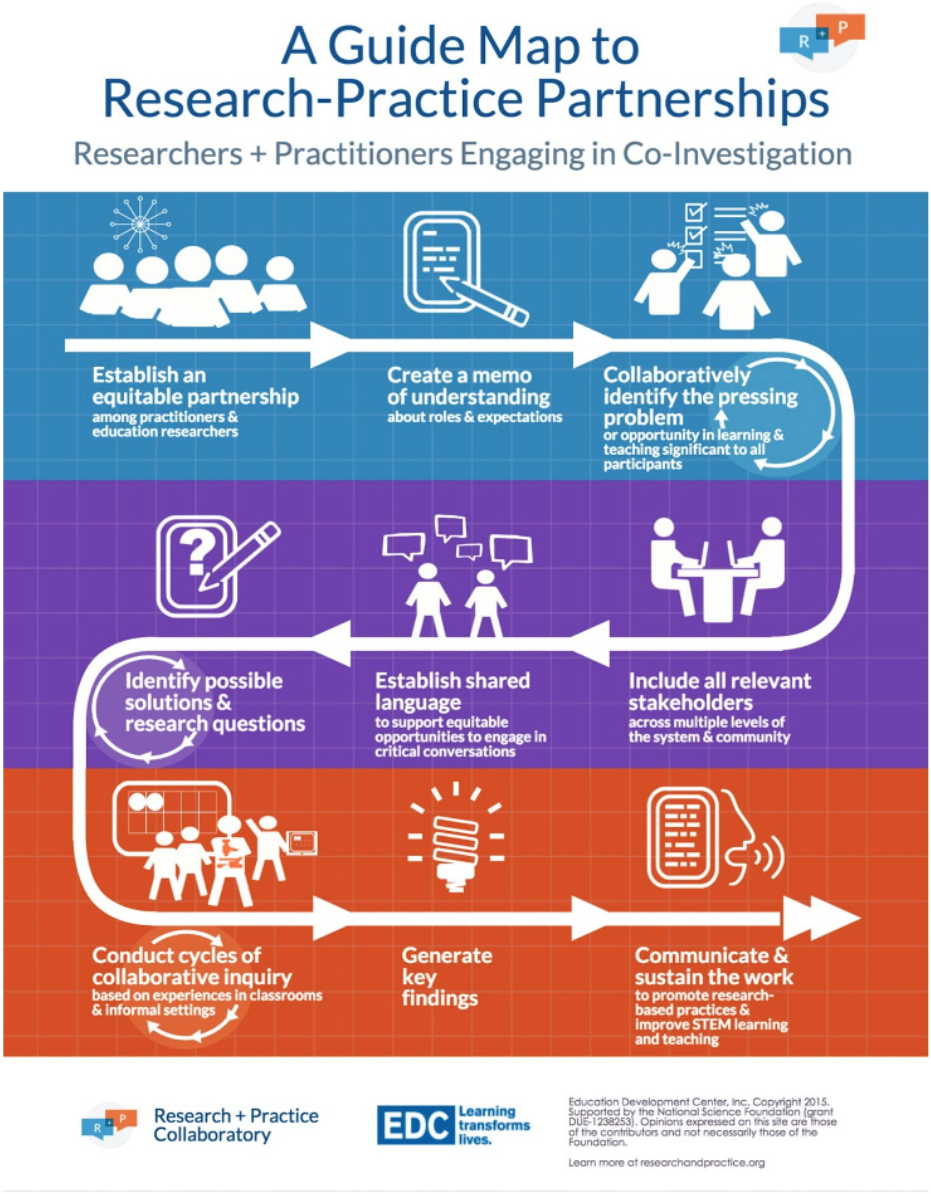


Figure 2.1: A Guide Map to Research Practice Partnerships

well as ensuring that collaborative researchers and practitioners are at the table and are active informers of the research (Wentworth et al., 2017; Wiebe et al., 2019).

Identify Possible Solutions & Research Questions. A critical step in the RPP is identifying solutions and implementing them (Muñoz, 2016 as well as formalizing the research questions that are to be addressed. Ecosystems help in this process by offering a "...powerful lens for researchers and stakeholders as they can answer the key problems of practice" (Wiebe et al., 2019).

Establish Shared Language. Inter-organizational practices for the RPP can ensure better communication and understanding across the research and partnership communities, including meeting routines to encourage communication and professional support (Frumin, 2019; Santo et al., 2017a).

Conduct Cycles of Collaborative Inquiry. Collaborative inquiry can be performed through a variety

of methodological approaches that are iterative in nature and test and refine the new educational approaches (Muñoz, 2016; Santo et al., 2017a; Schools, 2019). Methodologies can include exploratory research (Carroll-Miranda et al., 2019), narrative ethnography analytic approaches (Denner et al., 2019), comparative studies (Fall et al., 2019), qualitative approaches (Harrison et al., 2017), descriptive case studies (Kalir, no date), and a variety of other qualitative and quantitative methods (Cannata et al., 2019).

Generate Key Findings. A collaboratively developed research agenda is necessary for identifying how findings will be discovered (Boser and McDaniels, 2018; Coburn and Penuel, 2016; Fall et al., 2019). Findings are often generated using shared tools and common practical measurements (Frumin, 2019; Thompson et al., 2019), some of which may need to be developed for the RPP. Collaboration is also key in conducting the research within schools and school districts to collect the data needed for the findings. It is important to find meaningful ways to share findings as well as recommendations for change and action (Muñoz, 2016).

Communicate & Sustain the Work. Sharing implementation processes, communicating key findings for those who will implement the practices, and sharing key findings with other districts, researchers, and practitioners are all key aspects of an RPP (Hod et al., 2018; Muñoz, 2016). Sustaining the work via a continuous improvement model is necessary for the longevity of forming promising practices.

2.2.2 Implementation Frameworks

Primary models of partnerships (Penuel and Farrell, 2017) include:

- RPP Research Alliances - Typically focused on a specific district, region, or state for ongoing problems of similar interest (Cannata et al., 2019; Henrick et al., 2017)
- RPP Design/Co-Design models - Typically focused on the fully collaborative model of designing, studying, improving and then scaling classroom practices (to, for example, the entire school district) often based on promising practices as defined by empirical evidence (Cannata et al., 2019; Henrick et al., 2017; Henrick et al., 2016; Severance et al., 2014)
- Networked Improvement Communities (NICs) - often short-cycle improvement efforts, these communities engage education professionals, researchers, and designers to use a continuous improvement model for exploring the usage and refinement of promising practices that address shared problems (Cannata et al., 2019; Henrick et al., 2017)
- Hybrid - Two more of these methods combined (Henrick et al., 2017).

These frameworks will often contain the steps in the previous section, although their structure and organization may differ.

2.3 Roles and Responsibilities

RPPs are the long term strategy where practitioners and researchers come together and work in a highly collaborative manner to solve problems related to practice and find solutions for improving schools and districts (Cannata et al., 2019; Farrell et al., 2019). There are a number of studies discussing how researchers and practitioners can collaborate in RPPs and what common attributes are for achieving success (Henrick et al., 2016; Jacob et al., 2019; Stokes et al., 2018). Researchers and practitioners in RPP projects can work together to identify the problems and research questions (Bevan, 2017). They can access information needed through data collection and analysis. After analyzing the data they can answer their research questions and find solutions for the problems (Bevan, 2017). To close out the research cycle, researchers and practitioners work together to identify new problems of practice and research questions (Tseng et al., 2017).

Each study discusses how researcher's and practitioner's roles and responsibilities influence the outcome of the study. In all RPPs researchers and practitioners plan collaboratively to address researchers' interest and practitioners needs (Boser and McDaniels, 2018). For a mutual benefit and meeting the goals in an RPP it is important for both sides to know and fulfill their negotiated roles and responsibilities throughout the project (Connolly, 2019). According to a recent study, the quality of relationships between the two groups are "...important explanatory variables of evidence use above and beyond research relevance and rigor" (Wanzer, 2019, p. 3). To meet the goals for RPPs, and regardless of the engagement strategy or specific roles and responsibilities, the partnership between researchers and practitioners must be honest, transparent, and trusting (Connolly, 2019; Harrison et al., 2017; Stokes et al., 2018). Depending on each project and the framework of the study, the impact of meaningful partnerships have been shown to include:

- Positive changes in teachers self efficacy and sense of ownership by answering questions that matter to them,
- Improvement in the quality of teaching, scaling and new approaches for teaching, building bi-directional knowledge between researchers and practitioners,
- Researchers' deeper understanding of school contexts,
- Expanded professional communities that comprise practice-informed researchers, and
- Improvement in students' engagement and learning (Jacob et al., 2019; Santo et al., 2017a; Stokes et al., 2018).

Researchers and practitioners often have diverse roles. Researchers can provide the research plan, take a leadership role in structuring the shared learning, establish roles and responsibilities, support teachers' development of pedagogical content knowledge through balancing researcher and practitioner needs, collaborate with district leaders, put effort into being of service to practitioners, and provide evidence to support a strong model (Fall et al., 2019; Henrick et al., 2016; Schools, 2019). They act as knowledge brokers, connecting practitioners to other knowledge in real time as needed (Davidson and Penuel, 2019 and often bring connections to external supports for implementation and evaluation and disseminate findings (Connolly, 2019; Fancsali et al., 2019; Stokes et al., 2018).

While the term *practitioner* implies an array of practice-organization roles Kali et al., 2018, teachers are often regarded as a special population. They occupy a dual space as both the recipient of project interventions and a critical voice within the project. The goal of teacher engagement in the RPP is to "...foster and grow teacher leaders that participate in research in a variety of ways" (Wortel-London et al., 2019, online). Teachers may participate in design work to create classroom materials or take on leadership roles within the RPP, acting as conduits to their colleagues and representing the classroom perspective.

Roles and responsibilities of researchers and practitioners depend on the RPP type. In Research Alliances, their roles are distinct, and collaboration between them happens at the start and end of the project. The main responsibility of practitioners is designing and implementing the policies and programs, while researchers' responsibility is to evaluate the policies and programs (Penuel and Farrell, 2017). Research Alliances maintain an 'insider-outsider' perspective by acting as "independent voices in a community that document implementation and effectiveness" (Penuel and Farrell, 2017, p. 15).

The Design Research model shares elements with but is distinct from the Research Alliances model. The partnerships in this model are in long term collaborations. This model uses a co-design approach, and researchers and leaders work together in an iterative process in identifying challenges, test strategies, and finding solutions (Penuel and Farrell, 2017). Kali et al. notes that these tasks

require Design Centric (DC) RPP[1] participants to take on more than the traditional roles and often share responsibilities of consultant/facilitator, designer, and researcher (Kali et al., 2018).

In a NIC, there is no clear delineation of who is a researcher and who is a practitioner (Penuel, 2019; Penuel et al., 2015). However others have identified some basic functions of researchers and practitioners in NICs: researchers can take on the work of facilitating and guiding members through the improvement process (Thompson et al., 2019). Practitioners, then, take on responsibilities for developing measures, gathering, and analyzing data. In other words, in NICs it is assumed researchers and practitioners roles are counter-normative to their routine responsibilities (Coburn et al., 2013; Penuel and Farrell, 2017).

From the cumulative literature mentioned above we understand that researchers and practitioners can be assigned to varied types of roles and responsibilities. Since the RPPs are collaborative projects, the roles of researchers and practitioners are not always distinct and often can be blurred. Participants can also define and redefine their roles and responsibilities through the project (Farrell et al., 2019), with practitioners taking roles as researchers, and conversely researchers taking roles as practitioners (Ghiso et al., 2019). Additionally, both practitioners and researchers can be responsible for data collection, monitoring the fit of roles and responsibilities, gaining insight to problems of practice, and assessing needs through observations and listening. They may also bring stakeholders into the development of the project, its implementation and evaluation, and reporting the findings (Connolly, 2019; Fancsali et al., 2019; Stokes et al., 2018).

2.4 General RPP Benefits

Benefits of RPPs are multi-faceted and both researchers and practitioners can both be positively impacted due to the participatory knowledge building process (Santo et al., 2017a). They result in higher quality research that builds capacity among the researchers, practitioners, and their institutions that is more likely to have a positive, timely impact on students (Henrick et al., 2016; Muñoz, 2016; Stokes et al., 2018). By their vary nature, they are more equitable and ethical since they leverage ideas, assets, and "...community stakeholder experiences and perspectives to inform research questions, methods, and meaning-making" (Bevan et al., 2019, p. 1(Bevan, 2017; Henrick et al., 2016). This has the potential to discover interventions that have a higher adoption rate due to their usability and relevance in the local context (Bevan et al., 2019; Coburn and Penuel, 2016; Henrick et al., 2016; Hod et al., 2018; Stokes et al., 2018; Wille et al., 2017 since the rigorous research often provides better assurance that the new practices solve the targeted problem and are institutionalized (Bevan et al., 2019; Connolly, 2019; Stokes et al., 2018). This collaborative partnership also provides the platform for participants to "...self-reflect about how their own expectations influenced the RPP [which] has resulted in an honest description of the challenges that must be negotiated" (Denner et al., 2019, p.10), including those difficult challenges that district leaders face "...when attempting to make system wide improvements in complex education settings, particularly in high-needs priority schools" (Henrick et al., 2016, p. 26).

The outcomes of these many benefits include improved academic achievement among students (Coburn and Penuel, 2016; Schools, 2019; Stokes et al., 2018), student engagement (Stokes et al., 2018), and other social-emotional factors that have been shown to impact learning (Stokes et al., 2018). The networked community of those involved in the RPP are able to access the research and interpret it, and decision making can then be based on the interpretation of this research (Boser and McDaniels,

[1] Kali et al. (Kali et al., 2018 use the term Design-Centric Research Practice Partnerships (DC-RPPs). This includes, but is not limited to, Design Research. Other practices included in this term are design experiments, design-based research, design-based implementation research, and educational design research.

2018; Coburn and Penuel, 2016; Henrick et al., 2016). Tools and resources for improving curriculum can be provided and shared more widely (Stokes et al., 2018), and this generalized knowledge can extend beyond those involved in the RPP (Kali et al., 2018; Quartz et al., 2017).

The adaption of the continuous improvement model as a whole helps ensure continued use of "social resources" via continued networking as well as the continued sharing of ideas, processes, materials, and tools (Coburn and Penuel, 2016; Kali et al., 2018). Their long-term nature and open-ended commitment leads to the acceptance and use of the continuous improvement model dedicated to addressing persistent problems of practice (Coburn and Penuel, 2016; Dettori et al., 2018; Santo et al., 2017a and results in a significant amount of original data that is produced over time (Boser and McDaniels, 2018). Districts and state-wide policymakers then build "...their own capacity to use and generate research effectively" (Boser and McDaniels, 2018, p. 6).

In addition to their general benefits, RPPs have been shown to have a positive impact on individual researchers and practitioners (see Table 2.1). Benefits to teachers include increases in confidence and self-efficacy (Fancsali et al., 2019; Jacob et al., 2019; Stokes et al., 2018), improved classroom practices (Stokes et al., 2018), increases in sense of ownership of research (Jacob et al., 2019), and more awareness of advances in scholarship on improved teaching (Coburn and Penuel, 2016; Fancsali et al., 2019; Stokes et al., 2018). Researchers also share in benefits, including a deeper understanding of the realities of school contexts and practices (Kali et al., 2018; Stokes et al., 2018) and an increased confidence in the value of their work (Stokes et al., 2018).

There potentially may be another class of benefits that have yet to be documented by others or otherwise might go unstated, particularly at the macro level (e.g., policy, procedure, culture or subsets of the organizations participating in the RPP). These may include partnerships extending to new challenges and opportunities, development of trust allowing difficult conversations to occur, and acknowledgement and open discussion of power dynamics/power relationships by participants.

2.5 General Challenges

The first two hurdles that RPP initiators face are the ability to 1) form the collaboration and infrastructure for the RPP that can sustain change and 2) decompose the problem of practice that takes into account the holistic needs of learners for generating the RPP's focus (Kali et al., 2018; Resnick and Kazemi, 2019; Santo et al., 2017a; Santo et al., 2017b; Wiebe et al., 2019; Wille et al., 2016). Differing priorities, shifting goals, differing visions and approaches can all contribute to tensions among the RPP members (Boser and McDaniels, 2018; Denner et al., 2019; Henrick et al., 2017; Severance et al., 2014; Wanzer, 2019).

Over the multi-year course of RPPs, funding for sustaining the long-term collaborations often present a challenge (Bevan, 2017; Boser and McDaniels, 2018; Coburn and Penuel, 2016; Dettori et al., 2018). Likewise, RPPs can face organizational and knowledge management issues that plague any institution–finding and potentially hiring qualified researchers (Boser and McDaniels, 2018), employee turnover, sharing of research across the community of those involved, turnover in leadership, (Coburn and Penuel, 2016; Henrick et al., 2017; Santo et al., 2017a), time constraints (Coburn and Penuel, 2016; Henrick et al., 2017), complexities of the institutional and RPP hierarchies (Cannata et al., 2019 (including leadership structure (Dettori et al., 2018), social dynamics (Farrell et al., 2019), the needs of special interest groups external to the RPP (e.g. parents) (Cannata et al., 2019), lack of focus on the guiding goals (Santo et al., 2017a), and political influences within the RPP (Coburn and Penuel, 2016; Henrick et al., 2017). RPPs are also faced with similar decisions about choosing whether the benefits of the RPP outweighs the expenditure of funds to conduct the research (Muñoz, 2016).

RPPs may also bring to the forefront cultural gaps and differences, including those practices and

Group	Impacts
Teachers	Access to usable research (Stokes et al., 2018)
	Affirmation for long-term collaboration (Frumin, 2019)
	Classroom practices (Stokes et al., 2018)
	Confidence (Fancsali et al., 2019; Jacob et al., 2019; Stokes et al., 2018)
	Creating opportunities to develop and apply new knowledge (Coburn and Penuel, 2016)
	Engagement in professional learning (Stokes et al., 2018)
	Expanded professional communities (Stokes et al., 2018)
	Knowledge and awareness of important advances in scholarship (Coburn and Penuel, 2016; Fancsali et al., 2019; Stokes et al., 2018)
	Leadership capability related to STEM improvement (Stokes et al., 2018)
	Self-efficacy (Jacob et al., 2019)
	Sense of ownership (Jacob et al., 2019)
	Personal Identity (Frumin, 2019)
	Professional Renewal (Frumin, 2019)
Administrators	Expanded professional communities (Stokes et al., 2018)
	Personal Identity (Frumin, 2019)
	Professional Renewal (Frumin, 2019)
	Receipt of yearly feedback to support improvement (Henrick et al., 2016)
Researchers	Deepen their understanding of realities of school contexts and practices (Kali et al., 2018; Stokes et al., 2018)
	Expanded professional communities (Stokes et al., 2018)
	Increased confidence in the value of their work (Stokes et al., 2018)
	Increased confidence in outcome of their research (Kali et al., 2018)
	Personal Identity (Frumin, 2019)
	Professional Renewal (Frumin, 2019)
	Receipt of yearly feedback to support improvement (Henrick et al., 2016)

Table 2.1: Impacts of RPPs on practitioners and researchers based on previously gathered evidence.

policies that are inflexible and the awareness by the RPPs of those practices and policies that can be changed (Denner et al., 2019; Hazzan et al., 2018; Henrick et al., 2017). Likewise, they introduce a multi-party problem, which is amplified when the practitioners and researchers have no or only a limited history of interactions (Henrick et al., 2017) and have not been trained to work together (Wanzer, 2019). Many of these organizational complexities multiply as more members are added to the RPP (Tseng et al., 2017).

Power imbalances can inhibit the goals for equity and inclusivity in RPPs as well as inhibit the building of trust among RPP members (Bevan, 2017; Bevan et al., 2019; Denner et al., 2019; Ghiso et al., 2019; Henrick et al., 2017; Lash et al., 2019). This is further complicated by the complexities of communication among RPP team members (Wanzer, 2019), including issues of shared language (Santo et al., 2017a) and even communication about the partnership itself (Kali et al., 2018). Maintaining a local context on the partnership work can also be a challenge, particularly when there are other forces at play (e.g., politics, external fixtures that influence and can stress the partnership) (Henrick et al., 2017).

Equity within various aspects of the research, including the students, can be addressed in RPPs, but often there are "...complex and interrelated problems of practice associated with the creation and scale

of new practices that aim to position educators as techquity designers and brokers" (Kalir, no date, p. 6). In this regard, working towards justice also means that challenges can arise when considering if and when research should be conducted (Denner et al., 2019).

Building and maintaining trust among the RPP members can require significant time and commitment from the researchers and practitioners (e.g., teachers and district leaders) (Boser and McDaniels, 2018; Denner et al., 2019; Henrick et al., 2017; Henrick et al., 2016; Wanzer, 2019), which can be difficult when time is a known burden on staff and students that participate in the activities (Muñoz, 2016). RPP teams must also be flexible and adaptable, since at times the focus of the work must be shifted[2] (Santo et al., 2017a).

Sharing of the knowledge from the original data produced and lessons learned throughout the team as well as sharing of that data throughout the RPP can be a challenge (Santo et al., 2017a; Santo et al., 2017b). Even obtaining usable data, ensuring that practitioners understand the inquiry process and the scientific methods involved in inquiry, navigating between facilitating teachers and collecting data, and deciding on what data constitutes evidence needs to be navigated (Denner et al., 2019; Henrick et al., 2017; Jacob et al., 2019; Schools, 2019). Equitable sharing that presents the practitioners voice is also problematic, since findings are often presented at academic conferences and practitioners may not have the time or resources to commit to this endeavor (Ghiso et al., 2019). Research findings can also raise "...unanticipated and/or politically charged issues" (Henrick et al., 2017, p. 6) that must be navigated and data collection involves the establishment and maintenance of ethics related to privacy and confidentiality (Muñoz, 2016).

Research findings may also challenge the practitioners' fundamental beliefs (Coburn and Penuel, 2016 and institutional obstacles (Boser and McDaniels, 2018 and require that teachers take the time to shift their teaching to include practices related to findings (Stokes et al., 2018). These can affect implementation fidelity and quality (Bevan et al., 2019; Dettori et al., 2018). Teacher capacity building to engage in the RPP and the implementation of findings may be difficult to build (Dettori et al., 2018).

2.6 Assessing RPPs and Their Value

Assessment of RPPs is important in ensuring that the key components and the value of RPPs are being continually addressed. In this section we highlight several assessment methods.

2.6.1 The Five Dimensions of Effectiveness Model.

Although relatively new and not specifically designed for RPPs in CS, the Five Dimensions of Effectiveness assessment model (Henrick et al., 2017) has already been used and referenced across a variety of projects (Connolly, 2019; Henrick et al., 2019; Jacob et al., 2019; Lash et al., 2019) and has evidence of validity. In this model, RPP progress is measured across the following five dimensions:

- Building trust and cultivating partnership relationships
- Conducting rigorous research to inform action
- Supporting the partner practice organization in achieving its goals
- Producing knowledge that can inform educational improvement efforts more broadly
- Building the capacity of participating researchers, practitioners, practice organizations, and research organizations to engage in partnership work.

Various indicators are used across these dimensions to actual provide assessment measures. For

[2] A perfect example of this is the shifting required to address the impact of COVID-19 on the RPP team, the RPP's goals, and the impact on students

example, for the first dimension, *Building trust and cultivating partnership relationships*, there are 5 indicators (Henrick et al., 2017, p. 5-6):

- Researchers and practitioners routinely work together
- The RPP establishes routines that promote collaborative decision making and guard against power imbalances
- RPP members establish norms of interaction that support collaborative decision making and equitable participation in all phases of the work
- RPP members recognize and respect one another's perspectives and diverse forms of expertise
- Partnership goals take into account team members' work demands and roles in their respective organizations

By reading this assessment model, which is carefully aligned to best practices in establishing and implementing RPPs, one can derive a strong sense of how RPPs should be structured to acknowledge, support, and embrace the equal partnership RPPs seek to achieve.

2.6.2 The Wilder Collaboration Factors Inventory.

The Wilder Collaboration Factors Inventory can be used to assess the collaboration and partnership qualities among groups involved in an RPP (https://wilderresearch.org/tools/cfi-2018/start) (Connolly, 2019; Mattesich and Johnson, 2018). This vetted instrument has 44 questions across 23 factors that groups utilize. Factors include the history of collaboration/cooperation, flexibility, ability to compromise, open and frequent communication, and shared vision.

2.6.3 The RPPforCS Health Assessment.

Based on the Five Dimensions of Effectiveness model, the RPPforCS Health Assessment Tool offers a matrix for evaluators to evaluate the RPP design process over time to assess the maturity of the RPP (Zarch and Sexton, 2019). The Tool asks participants to identify the five dimensions of RPP effectiveness and their corresponding indicators and whether they have a) designed for this indicator, b) if the indicator is part of their documentation plan and c) if it is part of their reflection strategy. The tool then asks for an example of how the project has designed and how they document some element of each dimension (if relevant). The current iteration of the Tool was modified from the pilot which asked teams to rate their progress on each indicator based on their RPP community feedback. The Tool was produced as a Google spreadsheet, which allows easy inter-team collaboration and sharing with the RPPforCS research team.

Healthy partnerships will be proactive in giving their partnership attention. The Tool can help facilitate the design of the RPP and reflection among partners as a part of the trust building process. For RPPs that are struggling to function as healthy partnerships, the Tool may facilitate difficult conversations around where and how to improve the partner dynamics.

Early in the project the Tool can help frame discussions and set the intentions of the partnership. Engaging the RPP project evaluator early in the process allows them to design an evaluation that is aligned with the Health Assessment. Conversely, the health assessment is comprehensive. Not all dimensions or indicators will be appropriate at any one time so prioritize the areas of importance.

2.6.4 The Wentworth et al. Survey.

The assessment framework provided Wentworth et al. can be used to examine the impact of RPPs on behaviors, "such as educators' evidence-based decision-making, in the context of school and district improvement efforts" (Wentworth et al., 2017, p. 250). To support this assessment framework, the

authors developed a survey instrument that measures several key components of RPPs, including the "utility of the research and the partnership itself, the quality of the research produced by the partnership, the relationships within the partnership, the operations of the partnership, access to the research by practitioners and, generally, the amount of time it takes participants to interact within the partnership" (Wentworth et al., 2017, p. 250).

2.6.5 SWOT Analysis

A Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis was used to conduct an evaluation of RPPs in STEM in Israel (Groff, 1983; Hazzan et al., 2018). SWOT analysis is an well-known assessment measure used in businesses to help identify the strengths, mitigate weaknesses, seize on opportunities and identify threats, all in an effort to improve the processes and functions of an organization. In their analysis, for example, they found several strengths of RPPs across Israel, including that there were "...(a) multiple activities in STEM education, (b) a large research community in higher education departments in the universities that specialize in STEM subjects, and (c) other research institutions that engage in STEM education research and development" (Hazzan et al., 2018, p. 52). Although this particular use of SWOT was focused on multiple RPPs across one country, the concept of SWOT as an indication of each component at a particular point of time could potentially be useful for principal investigators/directors of RPPs in order to improve the processes.

2.6.6 Student Outcomes Assessment Model.

The Cannata et al. Student Outcomes Assessment Model uses a "difference-in-differences estimation strategy", which consists of a way to "...compare student outcomes among the innovations schools to the remaining schools in the district" (Cannata et al., 2019, p. 5). Outcome measures can (and should) be defined collaboratively with stakeholders (such as district leaders) based on the jointly desired outcomes. This can include a mixture of quantitative and qualitative measures, but should take the context of those partnership participants into account. To aid in the assessment process, the authors created a survey that can be found in Cannata et al.

3. Study Design and Author Reflexivity

3.1 Study Design

After reviewing the literature, it became apparent that, if the framework were to be carefully created, even one component would require extensive analysis and testing given the complexities of RPPs. In its entirety, this could easily result in a multi-chapter book. To better scope our research, we revised our methodology to better understand its complexity in relation to our needs. We took the following approach:

1. Carefully consider the literature and previously referenced components of an RPP
2. Blend this with our own understanding of RPPs to create a compositional structure for the framework
3. Consider what the first component should contain based on an analysis of the literature
4. Test the first component's structure for feasibility by vetting the components against a subset of NSF-funded RPPs
5. Prepare future work to further vet the proposed component structure
6. Prepare future work to build structures for each of the other components

We chose to complete the first four steps and leave steps five and six for future work.

3.2 Researcher Description and Author Reflexivity

We developed our research questions and chose to conduct this research based on our intensive work with the NSF CS for All: RPP community as computer science education researchers and evaluators. Within this capacity, we have relied upon our theoretical and practical knowledge of RPPs in general, our work within the CS education community, and the intersection of the two. The authors include education and computer science education researchers and practitioners (including former K-12 CS practitioners).

Our research analysis spans the next two sections, with Section 4 examining the creation of the broader framework to answer the first research question and Section 5 examining the first component of the framework. The former relies on our literature review and understanding of RPPs. The latter also relies on this information, and we also use a secondary content analysis to strengthen our work.

The coding for the content analysis was conducted by four of the authors. Two authors conducted the first phase of analysis, with one of the authors having experience conducting content analysis and other qualitative studies in computer science education and the other was a PhD student who worked

alongside them as a research assistant. Two other authors conducted the second phase of analysis, one of whom is a PhD student with a focus on organizational studies, gender inclusivity, and qualitative research, and the other who has been evaluating education programs and research projects for five years and who is closely involved with the NSF CS for All: RPP community. Both of the authors involved in the second portion of the analysis have education policy research interests.

We have brought our knowledge into this research in several ways. This research study itself was first borne from our desire to understand the uniqueness of RPPs for computer science education, particularly how they differ from RPPs in general disciplines. We understood that a more comprehensive literature review would need to be conducted to ensure that no other framework exists. This knowledge helped us focus and frame our research on key aspects of RPPs.

In creating the compositional structure for the broader framework (Section 4), we were able to draw upon our understanding of the structure of RPPs, their benefits, and their challenges to consider what a compositional structure might entail. Although the section is brief, this was necessary for us as we relied upon our previous knowledge to guide the development of this structure. For developing a framework for one of the sections, Theory of Change, we were able to again rely on our experience and knowledge of this theory to develop this (although we let the actual construction be guided by previous research). For vetting the Theory of Change framework using project data, we were able to utilize our existing collection of project abstracts data to expedite this process. We randomly selected 15 projects.

Throughout the remainder of this article, we reference when we rely on this knowledge more heavily to better inform the reader of when our own perspectives interject our understanding and interpretation of the content.

4. Framework for Analyzing Partnerships

To answer the first research question, *What would a broad framework for analyzing and comparing the partnership aspect of RPPs for primary and secondary computer science education entail?*, we first considered previous research as referenced in our background section (Section 2). In particular, we looked for previous research articles that presented categories for discussing and/or requirements for an RPP–not necessarily *processes*, but fluid, moving parts. Of the many articles reviewed in Section 2, works of two sets of authors stood out as a potential starting point:

- Penuel and Farrell state that the shared "DNA of RPPs" are the problems of practice they seek to resolve: mutualism, strategies to foster partnerships, and original analysis of data (Penuel and Farrell, 2017).
- Tseng et al. provide their own analysis of RPPs by defining four primary categories, including structuring the partnership (including long-term goals), developing shared commitments, producing and using research, and funding and similar partnerships (Tseng et al., 2017).

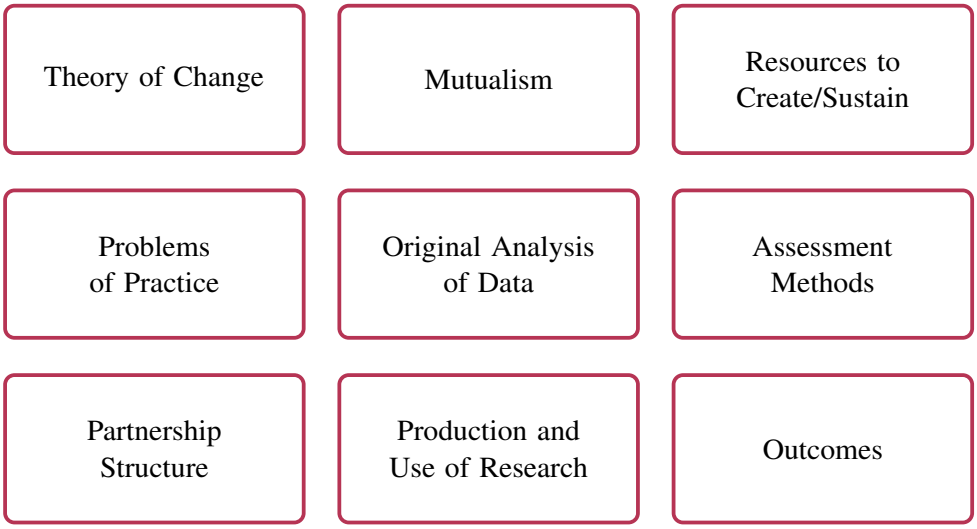
We combined these two to form the base compositional structure for our framework. We also drew from our own categorizations for partnership structure and organization that was built from the literature. The resulting components included the following:

- Problem(s) of practice in K-12 computing education that the RPP seeks to solve
- Partnership structure and organization
  - RPP framework
  - Roles and responsibilities
  - Long-term goals
  - Strategies employed that foster partnerships
  - Development of shared commitments
- Mutualism
- Original analysis of data
- Production and use of research
- Funding to create and sustain the RPP

Once we stepped back to reflect on this, we noticed that there was a core component missing that enabled the RPP to motivate change. We refer to this as an RPP's *Theory of Change* (Organizational Research Services, 2004 with the knowledge that establishing a Theory of Change is a critical piece of structuring and evaluating projects designed to change educational (and other types of) programs.

Further, although assessment measures and outcomes are not part of the categories established by

Table 4.1: Compositional Structure for Analyzing an RPP. The remainder of this report focuses on Theory of Change.



either Penuel and Farrell or Tseng et al., our and others' previous research in this area (see Section 2.6) indicates that assessment is a critical part of the continuous improvement process for long-term collaborations such as RPPs (Connolly, 2019; Henrick et al., 2017; Mattesich and Johnson, 2018; Zarch and Sexton, 2019).

Likewise, outcomes were not part of the original categories, but in the context of our goals for this article and future needs to see the pathways that RPPs take to meet intended goals, looking at what outcomes were being produced by the RPPs to date will provide insight into early findings from the RPPs. Finally, analysis of outcomes can also lead to a better comprehensive understanding of the types of outcomes funded by the NSF, how these correspond to what we know about academic achievement in the context of computer science and computational thinking and whether there are gaps in this understanding that remain to be filled. This also provides a component dedicated to examining intended and unintended outcomes, similar to those described in Sections 2.4 and 2.5).

We folded these additional categories (Theory of Change, Assessment Methods, and Outcomes) into the compositional structure, resulting in nine possible components that could be used to analyze and compare one RPP across multiple years or multiple RPPs (see Figure 4.1). Based on the literature and our own deep knowledge of RPPs, a thorough review by the authors and further discussion of these components as they align to the literature presented in Section 2, we consider these categories to be comprehensive and a valid starting point for vetting.

5. Component Analysis

To answer the second research question, *If we investigated one component of the framework, what would we learn from its analysis?*, we turned our attention to the first component, Theory of Change.

5.1 Structure for Evaluating the RPP's Theory of Change

A Theory of Change is an essential road map for achieving change in any organization and the structure for creating these theories are particularly well-suited for non-profits and educational institutions like RPPs. According to Organizational Research Services (Organizational Research Services, 2004), there are six primary steps for constructing a Theory of Change:

1. Clarify the goals
2. Identify powerful strategies to reach the goals
3. Create "so that" chains to define the outcomes
4. Link strategies with outcomes and goals
5. Test the logic and relevance
6. Articulate assumptions

We then examined each of these steps for constructing a Theory of Change to determine to what degree they could be used to analyze an RPP. We noted that step 5, test the logic and relevance of the Theory of Change, is a process of vetting the Theory of Change and not part of the Theory of Change itself. What remains are five steps that can be transformed into five guiding questions:

1. What are the goals of the RPP?
2. What strategies will (or did) the RPP use to meet those goals?
3. What are the pre-defined outcomes of the goals?
4. How do the strategies map to the outcomes and goals?
5. What are the underlying assumptions of the RPP (e.g., principles about how the RPP will operate or belief systems in place at the schools or within the communities)?

We postulated that these questions could potentially be used to analyze the Theory of Change in an RPP, such as its initial state, or across multiple RPPs. They could be answered by collecting several data points, including examining the original NSF proposals, examining materials from RPP strategy meetings, and interviewing the primary investigators of the project.

5.2 Data Collection

We decided to analyze secondary data to test our hypothesis and further analyze the Theory of Change component against the five questions. We conducted a random sampling of 77 unique RPPs from the first three funded cohorts, five across each year (2017, 2018, and 2019), for a total of 15 RPPs[1]). To perform the sampling, we divided the number of unique projects in each year and divided that number by 5 to get the *n*th value. We listed the RPPs alphabetically by year based on their titles. We chose every *n*th article for that particular year, yielding the projects in the Appendix.

Of these 15 projects, primary investigators from seven of the projects had previously shared their project descriptions. For the remaining eight projects, we relied on the project abstracts only that appear on the NSF website for awarded projects.

5.3 Data Analysis

5.3.1 Phase I Analysis

We decided to analyze the secondary data that we had (15 abstracts and seven project descriptions) by coding each against the five guiding questions. To familiarize ourselves with the data and gain a better of understanding of the types of codes that might be generated, we listed the project titles in a spreadsheet along with their project summary or abstract, research questions, intellectual merit statements and broader impact statements. We added five columns, one for each of the Theory of Change guiding research questions shown above. Once this was completed, we manually analyzed the data across each of the five categories (based on the questions above) to determine if this was a feasible way to disaggregate the data.

Once the data was established across all of these categories for each project, we placed the goals on a separate worksheet and summarized each into subgoals. For example, for one of the projects, the goal was stated as "A key project goal is to transform a collection of individual teachers into a South Carolina virtual community of 'activists' for broadening participation in CS education and to create a vibrant computing education community that is ready to generate interest and excitement about CS among all students." This goal became three subgoals, Create Virtual Community of Practice for Teachers, Recruit Teachers to Participate in Community of Practice, and Broaden interest in CS. Once these subgoals were established, 41 subgoals emerged. We classified the subgoals into different categories (e.g., Build teacher capacity) and is further discussed in Section 6.1.

After this analysis started, we noticed that it was inherently difficult to separate the "goals" text from other text in the project documentation. We quickly learned that a project's goals are not necessarily independent, and therefore, coding multiple goals per project made it difficult to assess the overall diversity of intended actions and equity dimensions planned for each project.

Many of the abstracts were rich in content related to Theory of Change, prompting us to consider that we may not actually need project descriptions for analysis–that we may be able to use the project abstracts to build this framework. This led us down a different exploratory analysis path.

5.3.2 Phase II Analysis

We conducted another analysis of the data, this time focusing only on abstracts and formalizing the process as follows:

- The 15 abstracts were uploaded and reviewed using Dedoose (qualitative analysis application)

[1] We did not include 2020 in this analysis, since the 2020 abstracts were not released until after this analysis took place.

- Subcodes for the Parent codes of Theory of Change, Actions, and Equity were generated based on the questions and coding scheme described in Phase I Analysis, with additional codes added for equity dimensions.
- The abstract as a whole was assessed for the presence of each code.
- Multiple subcodes from each parent code could be applied to each project.
- Each abstract was read a minimum of three times
- New codes were added when the existing categories did not seem to capture an action.
- New codes were integrated into existing subcodes, while other times they were created as a stand-alone subcode as appropriate. (See Table 6.6 for the complete list of derived codes.)
- Code frequencies were calculated for each subcode and parent code and reported.
- A limited number of code co-application dimensions were investigated.
- Another pass of the codes was conducted for verification of the codes generated.

After promising results in Phase II analysis, we formalized the codebook and identify additional areas of inquiry. We used consensus coding (Cascio et al., 2019 to assure inter-rater agreement. Each abstract was read and coded separately and coders met to resolve discrepancies in code application. For example, if only one rater applied the "Tailor" code, the coders would discuss this difference, come to an agreement about whether code application was warranted, and update their records to reflect this.

While the frequency of codes was generally stable between the first and second passes of the data in Phase II, some differences emerged.We attribute most of these changes to the formalization of the codebook between the passes. For example, in the first pass, nine abstracts were identified which included the Collaborate action family. In the second, five abstracts were coded with the Collaborate code, and 4 were coded with the new Create: RPP code, as we felt this was a better fit. In other cases, differences were a result of being stricter with applying the codebook criteria. This is most obvious with the Theory of Change elements (Table 6.4), where fewer abstracts were given credit for having clear outcomes and assumptions.

6. Component Analysis Results

6.1 Phase I Analysis: Goals

We first identified 41 subgoals from our Phase I analysis. Once sorted and grouped similarly, the following categories emerged: Type of Action to be Taken, Issues of Equity/Equity Dimensions, RPP Activities, Administrator Capacity Building, Teacher Capacity Building, Curriculum, and Community. We viewed the first two, the type of action to be taken and equity dimensions, to be complementary to the five remaining categories (see Table 6.1). That is, for every subgoal in the Teacher Capacity Building category, they each have a type of action ("Create," "Engage," etc.) and may possibly have an equity focus (e.g., girls, low performing schools, students with disabilities).

Components	Subcomponents	N	%
Action to be Taken	Create, Build, Design, Develop, Establish, or Implement	14	34%
	Examine, Investigate, Identify, Address	11	27%
	Teach, Train, Prepare	9	22%
	Support, Sustain, Strengthen, Refine	8	20%
	Recruit	1	2%
	Engage	1	2%
	Broaden	1	2%
Equity Dimensions	Unspecified	5	12%
	Girls	2	5%
	Low Performing Schools	2	5%
	Minoritized Students	1	2%
	Low Socio-Economic Status	1	2%
	Diverse Leaners	1	2%
	Disabilities	1	2%

Table 6.1: Phase I Analysis: Components of the goals are complementary to the components shown in Table 6.2.

When analyzing the 41 subgoals, we learned that 14 (34%) create or build and 11 (27%) examine/investigate. Equity dimensions included unspecified target demographics (12%), girls (5%), and low performing schools (5%). Table 6.1 lists the types of actions and equity dimensions found.

With respect to the target of the activities within the goals, we uncovered those related to the RPP itself (e.g., forming a new one or strengthening an existing one), teacher capacity, principal capacity,

		Count	%
Administrator Capacity	CT/CT Activities, CT Pedagogy	4	10%
Community	Principals	1	2%
Curriculum	Parents/Caregivers	1	2%
	Culturally Relevant Pedagogy	1	2%
	CS Relevance	1	2%
	CT Relevance	1	2%
	Lesson plans to integrate CT	1	2%
	Interest in CS	1	2%
	Scaffolded Instruction	1	2%
	CT Instructional Materials	1	2%
	CS Principles	1	2%
	Pathways	1	2%
RPP	New RPP	3	7%
	Existing RPP	2	5%
Teacher Capacity	PD in CS/CT	5	15%
	Community of Practice	2	5%
	PD to integrate CS	1	2%
	Culturally Relevant Pedagogy	1	2%
	Targeted/differentiated PD	1	2%
	Ongoing support	1	2%

Table 6.2: Phase I Analysis: These components of the goals show the target of the actions.

curriculum, and community engagement. We found that Professional Development in CS/CT was the most prominent focus of activities (5 or 15%) and CT/CT Activities/CT Pedagogy was next (4 or 10%). Table 6.2 lists the target activities found among the subgoals.

The goals grouping starts to shape a framework for analyzing the RPP activities (see Figure 6.1), which lends itself to understanding whether the NSF is meeting its planned objectives for the program as well as whether this aligns with what is known about building educational programs that boost academic achievement.

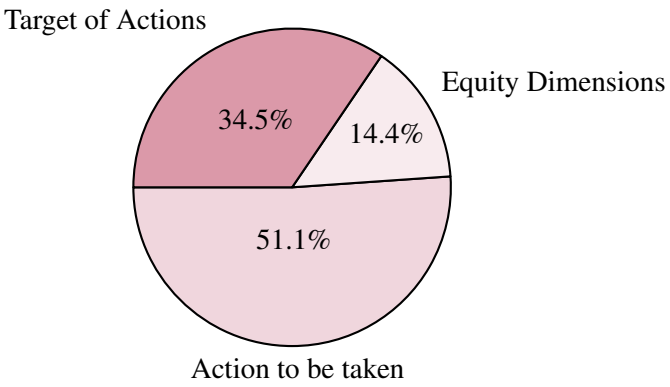


Figure 6.1: Phase I Analysis: Target of actions (N=31), equity dimensions (N=13) and actions (N=46) in the goals.

Action Family	First Pass		Second Pass	
	N	% of Projects	*N*	% of Projects
Create	13	87%	-	-
Context: CS Education	-	-	13	87%
Context: RPP	-	-	4	27%
Implement	-	-	4	27%
Leverage	-	-	-	0
(Leverage, expand, enhance)	10	67%	-	-
(Leverage, transform, enhance)	-	-	10	67%
Examine	9	60%	13	87%
(Collaborate)	9	60%	5	33%
Support	8	53%	5	33%
Teach	7	47%	8	53%
Engage	7	47%	3	20%
(Empower)	6	40%	-	-
(Empower, give voice, mobilize)	-	-	4	27%
(Raise awareness, disseminate)	-	-	5	33%
Broaden (transform)	5	33%	-	-
Broaden (expand)	-	-	3	20%
(Embed)	4	27%	1	7%
(Tailor)	2	13%	3	20%
(Hold accountable)	2	13%	1	7%
Recruit	0	0%	0	0%

Table 6.3: Frequency of Unique Actions.

6.2 Phase II Analysis: Exploratory & Rigorous Replication Analyses

Following our methodology described in Section 5.3, for Phase II Analysis, we used the project as the level of analysis, and all code counts were performed at the project level. The rationale for this decision was that doing provided a more holistic analysis of each project's Theory of Change.

6.2.1 Actions

There were seven unique actions that were found in the first analysis when looking at project goals only (see Table 6.1). However, in the Phase II analysis that examined the actions more holistically across projects, an additional six emerged as shown in Table 6.3 (with number of actions per project shown in Figure 6.2). When we look at the total number of elements used by projects in the the actions, the percentages are much lower here, even if the raw counts are similar. For example, the "Create" category had 13 codes in our sample and 14 in the original analysis. This meant while 87% of the 15 projects in our tabulation planned to create as part of their project, only 34% of 41 goals of the goal-level analysis were related to creation in the original coding application.

Since the Phase II analysis was more holistic, we would expect to find more codes. We note that only one action, recruit, was found in the first analysis and not in the second. This indicates that the recruit action was found in one of the project descriptions, but not in the project abstracts. This leads us with the hypothesis that 1) many of the projects include the majority of their actions in their abstracts and 2) additional codes may be added upon further investigation of additional documentation

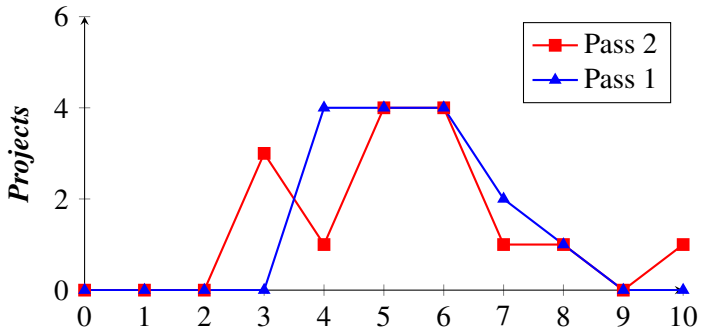


Figure 6.2: Number of Actions Found per Project. The yield from the first and second pass appear closely aligned.

or interviews with primary investigators.

We note that the Create action family is split into parts based on context. This was done during the second pass, as we thought it would be an important distinguish between whether the action was related to creating an RPP or creating new efforts of CS/CT education. We also thought it was important to distinguish contexts where the team was making a new product from scratch from those where they were putting in place an existing product. By increasing the precision of our codes, we can more easily create a typology of actions in future applications of the framework. We also recognize that contextualization can be added to all of the actions, and future use of the codes may be dependent on the ultimate goals of the researchers.

6.2.2 Equity Dimensions

Equity requires significant space when it comes to formal RPP practices (Denner et al., 2019; Henrick et al., 2017; Kalir, no date; Lash et al., 2019). Tables 6.4 and Figure 6.3 further quantify the framework for specifying the degree to which projects are pursuing multiple courses of action for multiple equity stakeholder groups. We note that the percentages appear much lower than in Table 6.1, since the equity dimensions in the first analysis was based on 41 subgoals rather than the total number of projects (15).

Equity Dimensions	First Pass		Second Pass	
	N	% of Projects	*N*	% of Projects
Race/ethnicity	8	53%	8	53%
Unspecified underrepresented	7	47%	2	13%
Economic disadvantage	6	40%	6	40%
All students	6	40%	-	-
All (including) students	-	-	6	40%
All (only) students	-	-	0	0%
Rural learners	5	33%	6	40%
Gender	4	27%	2	13%
Disability	3	20%	3	20%
English language learners	2	13%	2	13%
Other equity	-	-	3	20%

Table 6.4: Frequency of Equity Dimensions. Codes added during Phase II analysis appear in parenthesis.

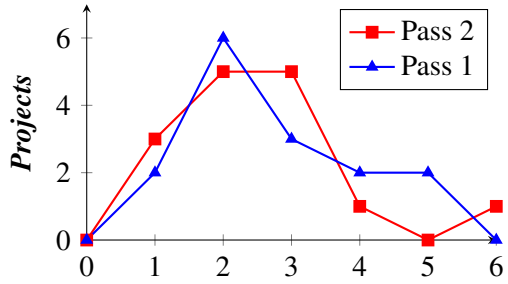


Figure 6.3: Number of Equity Dimensions in Projects. Pass 1 and 2 resulted in a similar count.

When analyzing the abstracts, we learned that many included multiple equity dimensions, even if only mentioning reaching unspecified additional disadvantaged students or expressing interest in reaching all students in addition to a specified population of students. Again, we recognized the overlap in codes between Phase I and II analysis, which led us to believe that these would be a reasonable addition to the framework. Another pass produced similar results, though some equity dimensions were less frequent due to stricter criteria for coding those dimensions after the codebook was revised. Interviews with primary investigators or investigating more project documentation would provide more completeness for individual projects.

6.2.3 Target Groups of Actions

Going into our second pass, we made the decision to include Target Groups of Actions as a unique set of potential codes (6.5). We initially created the codebook based on our collective knowledge of typical CS education and RPP project aims, and later added formal definitions for each code for reference by future coders. Both people (e.g., Teachers) and objects/concepts/activities (e.g., Curriculum; PD; Pedagogy) were included as potential targets. After we applied these codes to the 15 abstracts, we revised our codebook. First, we clarified the existing codes. For example, we made the decision to modify our code for Principals and Other School Leadership to read Principals and Other School Personnel to be more inclusive of non-instructional staff such as librarians, counselors, and curriculum support specialists. We then looked at all the excerpts to which we had applied the code "Other Target" to see if there were any new codes that emerged. We identified Barriers and Policy and Governance as potential codes to "promote" to the codebook in future analyses using this framework.

Since Targets of Action naturally correspond to Actions, two coders re-coded the 15 abstract set with the formalized codebook and coded all four dimensions of interest. When analyzing by number of targets, we found that all 15 projects incorporated four or more target groups for the actions (see Figure 6.4), indicating a multi-focus tendency.

6.2.4 Revised Codebook

These analyses only used project abstracts to ensure an equivalent amount of information was used to evaluate each project. Abstracts are publicly available and are often the first point of contact for an outsider to understand the project. Of the original codes that emerged from Phase I analysis, only one code (Recruit) did not emerge from the Phase II analysis (see Table 6.6). This indicates a significant overlap between codes generated from the goals from which the abstract and project descriptions were used (Phase I Analysis) and Phase II Analysis in which only the abstracts were analyzed at the project level. This provided us with confidence that the Phase II Analysis based on abstracts could yield sufficient results to form a comprehensive codebook for the Theory of Change (first component in

Grouping	Target Group	# of Projects	% of Projects
Administrators	District-level administrators	8	53%
	Principals and Other School Leadership	10	67%
Community	Community organizations	3	20%
	Families	2	13%
Pedagogy	Curriculum	9	60%
	Pedagogy	6	40 %
Research	Research or Researchers	10	67%
Teachers	Teachers	13	87%
	Professional Development	10	67%
RPP	RPP or RPP members	11	73%
Students	Students	11	73%
Other Target	Other	6	40%

Table 6.5: Unique Targets of Action per Project.

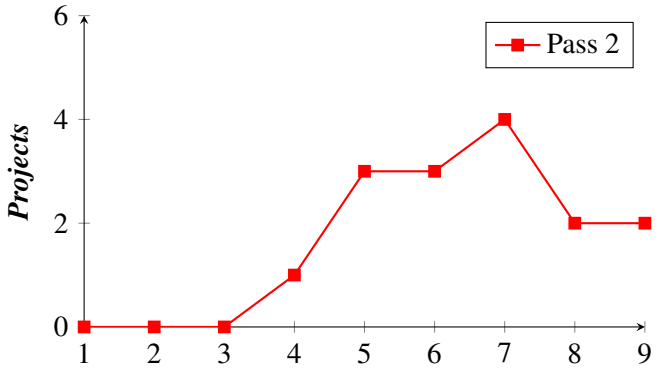


Figure 6.4: Number of Targets per Project.

Figure 4.1).

The codes also differ from what is presented in Table 6.1 in another way. We added the five categories of Theory of Change (clarity of goals, strategies, outcomes, strategy-outcome relationships, and assumptions) as stand alone items in the codebook. This provided us with the ability to include specific elements of the Theory of Change (see Section 5.1) and determine the completeness of the Theory of Change presented by a given project. These five categories were drawn from the six elements of a Theory of Change outlined in 5.1. Item five (test the logic and relevance) was considered to be too subjective to code and was excluded from the codebook and analysis. This also set the stage for our rigorous replication pass, which confirmed and clarified codes.

It is critical to note that this analysis does not necessarily point to deficiencies in the project abstracts. Abstracts are written at a separate time than the project description without clearly delineated expectations. Instead, the purpose of this analysis was to determine if this would be a valid method for analyzing the Theory of Change in an RPP as a whole.

Grouping	Code
Actions to be taken	Create, build, design, develop, establish, implement
	Examine, investigate, identify, address* (evaluate, assess)
	Teach, train, prepare (introduce)
	Support, sustain, strengthen, refine (inform, assist)
	Recruit
	Engage
	Broaden (transform)
	(Collaborate, bring together, partner)
	(Embed, infuse, integrate, formalize)
	(Empower, give voice, mobilize, raise awareness, disseminate)
	(Hold accountable, address)*
	(Leverage, expand, enhance)
	(Tailor)
Equity Dimensions	Disability
	Economic disadvantage
	English language learners
	Gender
	Race/ethnicity
	Rural learners
	(All students)
	(Unspecified underrepresented)
Theory of Change	Goals clear
	Strategies clear
	Outcomes clear
	Strategy-outcome relationship clear
	Assumptions clear

Table 6.6: Revised Codebook. Codes added during the Phase II analysis appear in parentheses.

6.2.5 Theory of Change

Table 6.7 shows one way to analyze the Theory of Change in a project–analyzing how clearly these elements are present. The goals were clear in all project abstracts, and 14 (93%) had clear strategies. Of the four projects which had both clear strategies and outcomes, two had a clear relationship between the strategies and outcomes.

Figure 6.5 shows the degree to which projects have a complete Theory of Change. Most project abstracts included at least two or three elements of a Theory of Change. Another pass with a formalized codebook and stricter guidelines for coding produced similar results. This assured us that it is possible to include these elements within a framework for the Theory of Change, as it is likely that we could distinguish more of these elements through interviews with the primary investigators or through project descriptions.

Theory of Change Element	First Pass *N*	First Pass % of Projects	Second Pass *N*	Second Pass % of Projects
Goals clear	15	100%	15	100%
Strategies clear	14	93%	14	93%
Outcomes clear	6	40%	4	27%
Strategy-outcome agreement	2	13%	3	20%
Assumptions clear	4	27%	1	7%

Table 6.7: Theory of Change by Element (n=15).

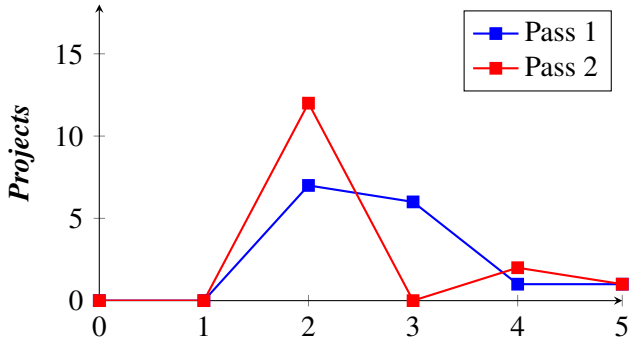


Figure 6.5: The Number of Theory of Change Elements across Projects.

7. Discussion

7.1 Central Contributions

The framework shown in Figure 4.1 provides a start in creating the foundation for analyzing an RPP. Once we analyzed the Theory of Change component and developed a way to analyze the CS for All: RPP project abstracts, we derived a comprehensive codebook (see Appendix B) that was tested against 15 project abstracts with meaningful results. This work is significant, since a framework for analyzing RPPs individually or comparing/contrasting across RPPs did not previously exist.

The Theory of Change was the first component that we analyzed and we let the data guide the emergence of the codes. We learned that what was being done, for whom, and how were captured in many project abstracts. From our first analysis of goals, we learned that a given project may have equity expressed in each subgoal, showing the strength of integration into the overall project.

Though we used a small sample size, we were able to establish a grouping of the projects' goals (Table 6.1). This grouping starts to illustrate what types of RPPs are being funded, which lends itself to understanding whether the NSF is meeting its planned objectives and whether this aligns with what is known about building educational programs that boost academic achievement. This prompts other questions: is this what is generally found in all RPPs or for all RPPs funded by the NSF? Or is there a uniqueness here that can be attributed to its context of computing education?

7.2 Similarities and Differences from Prior Theories/Research Findings

As articulated earlier, the field of RPP research is still under development. Though there has been previous work into analyzing RPPs, little has been done in the way of analyzing RPPs as a whole. Therefore, this section examines our derived codes against the literature called out in Section 2 to determine if parallels exist. Section 7.2.1 revisits how the major components materialized and Sections 7.2.2, 7.2.3 and 7.2.4 examine the Actions, Targets Acted Upon, and Equity Dimensions, respectively, as they relate to the first component, Theory of change.

7.2.1 Major Components

The major components of the framework (Figure 4.1) was developed through the literature and our knowledge of RPPs. Although no previous research provides a framework as complete as the one we offer, the components were derived directly from previous research, with the basic components derived from Penuel and Farrell and Tseng et al. (Penuel and Farrell, 2017; Tseng et al., 2017). The Assessment Methods and Outcomes components were added after revisiting the literature and acknowledging the important role they play in RPPs (Connolly, 2019; Henrick et al., 2017; Mattesich and Johnson, 2018;

Zarch and Sexton, 2019). Theory of Change plays an important role in designing programs intent on solving problems of practice (Organizational Research Services, 2004).

7.2.2 Actions

Reflecting on the actions discovered and how those relate to previous research, we start with the Create family of actions. One of the first steps of RPPs is the establishment of the partnership (Connolly, 2019; Lash et al., 2019). Further, the identification of possible solutions can require the creation of capacity building for teachers and schools to offer CS and CT instruction (Fancsali et al., 2019; Wille et al., 2016). Implementation considers those components of pedagogy, curriculum, PD or other existing material that only needs implementing to meet the RPP's objectives and can lend itself to capacity building (Fancsali et al., 2019).

It is no surprise that the Teach family actions appear frequently within RPPs, given the nature of these RPPs being situated within the context of education–our coding found roughly half of the projects take this action. More unique, however, is the empower, give voice, mobilize code, which is an action that is measurable and driven by the NSF call for proposals while at the same time being a critical piece of an RPP (Penuel and Farrell, 2017; Santo et al., 2019). The Engage code is also key to this, as it is a necessary part of mutualistic collaborations (Henrick et al., 2016; Penuel et al., 2015 as well as an effective teaching mode. Both of these appeared lower in the abstracts than we might expect, given the CS for All calls' emphasis. We cannot, however, be sure if this was merely unstated in the abstract or efforts were not being made in the projects for intentional reasons or an oversight in the project itself.

As indicated by their title, research is a critical part of RPP's foundation (Hod et al., 2018; Lash et al., 2019; Penuel and Farrell, 2017) and this is considered in our codes (Examine, Investigate, Identify, Evaluate, Assess). This is necessary for the continuous improvement science that is integrated into RPPs (Shakman et al., 2017). Likewise, raising awareness and disseminating findings is an important part of the RPP framework and is included in the NSF proposal call and a part of the fundamental steps for an RPP (Hod et al., 2018; Lash et al., 2019; Muñoz, 2016).

7.2.3 Targets Acted Upon

Santo et al., Stokes et al., and Jacob et al. all suggest that RPPs can have positive impacts on teachers' self efficacy and sense of ownership of the work; improve the quality of teaching and ability to scale new approaches; expand professional communities; and lead to improvement in students' engagement and learning (Jacob et al., 2019; Santo et al., 2017a; Stokes et al., 2018). Looking at the Targets for these RPP actions, the sample of RPPs appears well positioned to achieve similar benefits. 13 projects target teachers, 11 target students, 10 each targeting Principals and Other School Leadership, PD, and Researchers themselves. These intended targets are aligned with work that is known to impact student learning: teachers, instruction, and building-level support for teachers (Farrington et al., 2012; J. Lee and Shute, 2010).

Though the NSF hosted several workshops to support projects writing proposals for the CS for All: RPP solicitation, we were still slightly surprised to see such a large portion of the sample (73 percent) state a focus on the RPP or RPP members. This suggests an awareness that the RPP approach requires intentional focus, effort, and planning (Henrick et al., 2016).

Six of 15 abstracts coded identified at least one target for which we had not generated a code. Of these "Other Targets," four of them related to Policy, State Administrators, or governance structures. This is aligned with what Penuel and Farrell offers as a potentially important impact that RPPs can have, given RPPs production and utilization of data that can be applied to the policy process.

7.2.4 Equity Dimensions

Lack of focus on guiding goals is a known challenge to RPPs (Santo et al., 2017a). Projects generally can be seen to take on multiple actions (Tables 6.4 and 6.3) and multiple dimensions of equity they hope to positively impact. Projects clustered around five or six actions, impacting between five and seven targets, and addressing 2-3 equity dimensions. It is unclear how projects intend to manage and navigate these multiple goals and actions. It may be necessary, however, for RPPs to take on such complex work to make progress against their problems of practice. As Kali et al. reminds us, "complex interrelated problems of practice are associated with the creation and scale of ..."techquity" (Kalir, no date). This implies that even one area that an RPP may have goals around, or have a Theory of Change to impact, may itself be composed of many component problems of practice, demonstrating the inherent complexity of RPP work.

7.2.5 Theory of Change

Having a well-defined and agreed upon Theory of Change or Action is crucial to the functioning of the RPP and for being able to assess the RPP as part of a continuous improvement cycle (Davidson and Penuel, 2019; Henrick et al., 2016; Penuel and Farrell, 2017). The Theory of Change needs to be well-defined to articulate how each element of the proposed work fits into the overall Theory of Change for the program (Davidson and Penuel, 2019). (Penuel and Farrell, 2017 acknowledges that projects' Theories of Change can also be influenced by the funding organization. In this work we did not formally examine the extent to which projects' actions, targets, and equity target were aligned with NSF priorities. In our sample of 15 abstracts, we found that the two most commonly articulated elements of a Theory of Change were the Goals and Strategies. We imagine that in the full proposal projects are able to articulate each of the other elements, though this would require future work to examine empirically.

7.3 Alternative Explanations of Findings

While we are confident that our theoretical reasoning is correct, we also entertain that there may be another path of influence that has led almost every project we reviewed to include the same actions, targets, and basic pattern of presenting the Theory of Change. Taking this viewpoint, we could view the "NSF abstract" and the proposal that it is drawn from as its own genre of academic writing. Since NSF application are formal, structured, and competitive, we can borrow from institutional theory (Meyer and Rowan, 1977 and suggest that authors are striving to highlight the legitimacy of their proposals and are not necessarily concerned with providing complete concise summaries of their projects in their abstracts. Because they are concerned with appearing legitimate, they may over rely on the elements included in the abstracts of previously funded projects, and thus the isomorphic forces (DiMaggio and Powell, 1983 acting in the field of NSF proposal writing are responsible for the degree of similarity and not a rational reason related to the needs and successes of RPPs.

Another possibility, which would require further study, is the degree to which the NSF abstracts correspond with the specific language used in the NSF solicitations, or if we could see a shift over time in response to the shifts within the solicitation language and priority areas. This type of research cannot be extricated from the policy process, and NSF as a funder, can shape the directions of fields of study through their language, guidance, and call for proposals (Penuel and Farrell, 2017).

7.4 Strengths and Limitations of this Study

Though we performed an extensive review of literature about RPPs for Section 2, we did not perform a formal systematic literature review. Given this, there may be additional articles with results that could supplement or contradict findings from other studies. A systematic literature review could lead to modifications to the components in the compositional structure (Figure 4.1). Additionally, as each component's composition is considered, this may add to insight about the compositional structure itself, including whether there are too many or too few components, or if components have overlapping features.

Coding in Phase I analysis was limited to seven project descriptions and 15 abstracts, and coding of the Phase II analysis was limited to the abstracts. By limiting the analysis to the NSF abstracts, some key information for which codes could be derived could have been omitted. For example, a project by Chicago Public Schools aims to make CS instruction available to all high school students. While the abstract specifically mentions the equity dimensions of gender and race/ethnicity, it does not explicitly mention other diversity dimensions that would be included in a population of "all high school students," such as students with disabilities and English language learners. Phase II analysis also included a code only once for a project, even if an abstract made multiple references to a concept or action. This could be remedied in future code applications to determine the relative focus on a particular action in the text.

The amount of information that can be gleaned from the abstracts may not be enough or may not be accurate enough for the intended purpose of the analysis. Further, there is no requirement from NSF that the abstract must contain all details of the proposer's Theory of Change. However, looking at a set of 15 and then comparing this to future projects can help ensure that this model works at the level needed for understanding what the RPPs are trying to achieve holistically. Additionally, we do not currently have access to a dataset which would allow us to examine project-level outcomes to map against a project's Theory of Change, thus we cannot speak to the quality of the Theories of Change themselves or their efficacy in structuring the work to produce said outcomes.

An interesting question about this framework is whether it is specific to CS RPPs or if it could be generalized to other disciplines. Any RPP focused on equity, for example, may be able to use the same codes. Likewise, the Theory of Change codes are general and can easily be applied to RPPs. What remains unclear is how the actions could be specific to the RPPs for CS or whether they may be more generalized. To determine the transferability of these codes, a study would need to be conducted with the framework to explore abstracts from other disciplines and determine if they produce similar results.

7.5 Ethical Dilemmas or Challenges Encountered

One significant dilemma we encountered was the degree to which we, as the coders, should read into the abstracts that we read or give the project team the benefit of the doubt when assessing the completeness of their conceptualization. We understand that proposals, projects–and RPP projects especially due to their complex team composition–cannot be miniaturized to an abstract in a way that completely captures their thinking, intentions, and capabilities.

We also realized that this method of relying on the abstract may advantage writers who can provide a compelling description, but whose projects will fail to meet their well-communicated goals and expectations. Therefore, we position this framework as developed from abstracts, but cautioning that, without further validation, it would be misguided to use this framework to make value judgments about the projects or predict project outcomes. To mitigate this, we have begun the process of vetting the Theory of Change disaggregation model via additional analyses.

7.6 Implications for Future Work

Additional analysis is currently underway to refine the codebook and examine all 117 of the unique NSF CSforAll project abstracts against its completeness. Additional research that could be performed includes 1) adding descriptive categories to each project to look for intersections between RPP type, funding amount, age, etc and the number and type of elements present in each NSF abstract, 2) reducing the action codes into theoretically meaningful categories, some examples include Concrete vs Abstract and Research focused vs Implementation focused, and 3) focusing on why RPPs need comparative frameworks, and how, when, and by whom the analysis would be performed, with what external outcomes. This then provides greater focus on which elements of the many possible facets of RPPs should be included in an analytic framework.

There are additional elements based on the review that might be part of the Theory of Change, but also may be appropriate for one of the other components. These include project implementation personnel (e.g., researchers, school personnel), intervention target (e.g., student, parent, teacher, school), theoretical basis for the intervention (e.g., self-efficacy, unplugged computing), and aspects of equity that the intervention addresses (e.g., economic disadvantage, race/ethnicity).

As part of the larger compositional structure of the broader framework, analyzing each component as we have done for the Theory of Change component will provide a thorough method of analyzing projects. Researchers could then investigate one of the components across several projects (e.g., in a comparison/contrast case study approach) or all components against one project to learn more about how one project functions. This can then serve a further purpose of providing additional information to funding agencies like the NSF to understand what their monies are funding and whether efforts are meeting agencies' objectives.

8. Conclusion

This qualitative research study was conducted to explore how to analyze RPPs to learn more about them. We proffer a framework for comparing and contrasting RPPs as well as analyzing a single RPP (potentially using case study research methods). Our compositional structure for the framework with independent components can be separated for conducting analysis or can be used in whole. Further, we created a framework within one of the components, Theory of Change, that could be used to analyze a single RPP or to compare multiple RPPs and serve as a model for creating analysis frameworks for other components. The framework was created through two methods of analysis to confirm the utility of our approach, with overlapping results. This provides further confirmation that our methodology and the framework is robust. Future analysis includes examining all 117 unique RPP project descriptions (2017-2020) to see if the Theory of Change framework holds.

The value of this work extends beyond the RPP for CS community. Creating a way to learn why some RPPs make more progress than others and what variables and factors contribute to this has the potential of redefining how RPPs are structured and function. As we continue this work, we are also keen on learning how RPPs for CS are differentiated from RPPs in other disciplines and fields.

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A. Selected Projects

CAFECS: Collaborative Research: Chicago Alliance For Equity in Computer Science (McGee, 2017

CS For All: RPP: A Scalable RPP for Preparing and Supporting Teachers to Teach Culturally Responsive and Rigorous CS Courses in SC High Schools (Che et al., 2017

CT4EDU: Broadening Pathways into Computing by Developing Computational Thinking Competencies in Elementary Classrooms (Yadav et al., 2017

Integrating the Computer Science and Computational Thinking in Three Rural Eastern North Carolina School Districts (Militello et al., 2017

Personalized Computational Thinking for Grades 3-8 (Asbell-Clarke et al., 2017

Addressing Issues of Equity and Engagement in Computer Science (CS) through a Research Practice Partnership: The CS Teaching and Learning Collaboratory (Cynthia Blitz et al., 2018

Collaborative Research: Identifying Participation Barriers to Computer Science Education in Rural Mississippi (Hollis, 2018

Developing board games and learning materials to support 5th grade students' connected learning around computational thinking and coding (V. Lee et al., 2018

Equitable Computer Science Implementation in All New York City (NYC) Schools (Mark and Patel, 2018

Preparing K-5 Teachers to Integrate the Computer Science Standards of Learning in Inclusive Classrooms to Support Students with High Incidence Disabilities (Hutchison et al., 2018

Collaborative Network of Grades 3-5 Educators for Computational Thinking for English Learners (Mark Warschauer et al., 2019

CS for Appalachia: A Research-Practice Partnership for Integrating Computer Science into East Tennessee Schools (Hodge et al., 2019

Exploring Computation Integrated into Technology and Engineering (ExCITE) (Gordon et al., 2019

K12 CS Pathways for Rural and Tribal Schools (Rosato and Treichel, 2019

RUI: Empowering K-5 Teachers in Southern Oregon Through Computational Thinking (Skuratowicz et al., 2019

B. Revised Theory of Change Codebook

B.1 Theory of Change Codes

Clear Theory	Definition: Project team...
Goals clear	Clearly describes at least one goal for the project
Strategies clear	Clearly describes at least one activity that will be used to meet project goal(s)
Outcomes clear	Clearly describes the outcome(s) that will be used to determine progress against the goal(s)
Strategy-outcome relationship clear	Describes both strategies and outcomes and the coder can interpret a realistic way that the outcomes could be reached through the described strategies
Assumptions clear	Mentions at least one factor that underlies success or may hinder attainment of the goal(s)

Table B.1: Theory of Change Codes

B.2 Equity Dimensions Codes

Equity Dimensions	Definition
All (only) students	Only mentions all students
All (including) students	Mentions all students as well as one or more specific equity dimensions
Disability	Mentions students with disabilities
Economic disadvantage	Mentions students with an economic disadvantage
Gender	Mentions girls, women, or otherwise addresses gender issues
Race/ethnicity	Mentions race and/or ethnicity
Rural learners	Mentions rural learners
Unspecified underrepresented	Only mentions unspecified underrepresented students
Other Equity	An equity dimension not otherwise covered in the codebook

Table B.2: Equity dimensions codes that rest within the Theory of Change.

B.3 Target of Actions

Target of Action	Definition
Community organizations	Those outside of the direct instruction or school administrative structures (e.g. local businesses or non-profits)
Curriculum	The content of instruction
District-level administrators	Any official operating within the administrative structure of a district
Families	Parents and care-givers of students
Pedagogy	The process of instruction
Principals and Other School Personnel	Any school-level personnel or administrators (including counselors, librarians, and curriculum support specialists)
RPP or RPP members	In aggregate the enterprise of "partnership" as implied in "RPP" or any singular component or member thereof
Students	K-12 students
Teachers	Classroom instructors
Other Target	A target not otherwise covered in the codebook

Table B.3: Target of Actions that rest within the Theory of Change.

B.4 Action Codes

Action Family	Examples of Actions	Definition: Project team will...
Broaden	Broaden, expand	Expand access to a program or fundamentally change a key aspect of a project
Collaborate	Collaborate, bring together, partner	Facilitate interaction among parties that may not have done so without this intervention
Create	Create, build, design, develop, establish	Undertake at least one new activity that involves a new curriculum, working group, product, or method, etc.
Embed	Embed, infuse, integrate, formalize	Work to integrate intervention changes into the practitioner spaces so that they last beyond the project's end
Engage	Engage	Motivate individuals to participate in the project as researchers, practitioners, or students
Empower	Empower, give voice, mobilize	Encourage action among and beyond the researchers, practitioners and/or students in the project
Examine	Examine, investigate, identify, evaluate, assess	Collect and analyze data to understand the situation
Hold accountable	Hold accountable	Ensure that researchers and/or practitioners uphold the goals of the project
Implement	Implement	Project team will deploy existing material
Leverage	Leverage, transform, enhance	Use existing resources as a springboard from which to launch a new or changed initiative
Raise awareness	Raise awareness, disseminate	Encourage knowledge sharing among and beyond the researchers, practitioners and/or students in the project
Recruit	Recruit	Seek out new individuals to join the project as practitioners or students
Support	Support, sustain, strengthen, refine, inform, assist	Either directly or indirectly impact structures or practices
Tailor	Tailor	Mindfully adapt the intervention to the specific needs of an educational space
Teach	Teach, train, prepare, introduce	Transfer knowledge to researchers, practitioners and/or students or otherwise develop practitioner capacity to meet goals

Table B.4: Action Codes that rest within the Theory of Change.