E□ective Teacher Professional Development

Linda Darling-Hammond, Maria E. Hyler, and Madelyn Gardner,
with assistance from Danny Espinoza

LEA

E□ective Teacher Professional Development

Linda Darling-Hammond, Maria E. Hyler, and Madelyn Gardner,
with assistance from Danny Espinoza

The appropriate citation for this report is: Darling-Hammond, L., Hyler, M. E., Gardner, M. (2017). *Effective Teacher Professional Development*. Palo Alto, CA: Learning Policy Institute.

This report can be found online at https://learningpolicyinstitute.org/product/teacher-prof-dev.

Table of Contents

Defining E□ective Professional Development

In this review, we de f ne effective professional development as structured professional learning that results in changes to teacher knowledge and practices, and improvements in student learning outcomes. We conceptualize professional learning as a product of both externally provided and job-embedded activities that increase teachers' knowledge and help them change their instructional practice in ways that support student learning. Thus, formal PD represents a subset of the range of experiences that may result in professional learning.

This Study

In this paper, we examine the research on professional learning that has proven effective in changing teachers' practices and improving student outcomes to identify elements prevalent in successful PD models. To de f ne features of effective professional development, we reviewed 35 studies that emerged from our extensive search of the literature over the last three decades which met our methodological criteria: They featured a careful experimental or comparison group design, or they analyzed student outcomes with statistical controls for context variables and student characteristics. (Appendix A details our methodology and Appendix B details each reviewed study.) We coded each of the studies to generate the elements of effective PD models. Appendix C indicates the elements exhibited by each of the PD model(s) featured in each study.

This paper offers rich descriptions of the combined characteristics of professional development that research has found to positively relate to student outcomes.

We recognize that this methodology has limitations. Because studies of professional development typically examine comprehensive models that incorporate many elements, this paper does not seek to draw conclusions about the eff cacy of individual program components. Rather, it offers rich descriptions of the combined characteristics of PD that research has found to positively relate to student outcomes.

We are also unable to comment on the studies of PD that do not appear to yield positive results on student achievement. Although many studies lack the rigorous controls needed to draw inferences about outcomes, there are a number of well-designed studies of PD that share some of the features we highlight here but did not f nd positive effects. We located six studies with strong methodologies that failed to f nd impacts on student learning. Several found positive in f uences on teacher knowledge and/or practices but not on the measure of student outcomes used.[8] These measures of student outcomes were sometimes designed to evaluate the speci f c goals of the PD and sometimes were a more generic commercial instrument or state test.

Authors noted a number of potential reasons for their f ndings, including lack of implementation f delity in the conduct of the PD,[9] lack of opportunity for teachers to implement what they learned in the PD in their classrooms,[10] and teacher turnover that reduced many teachers' access to the PD.[11] In one study, Garet and colleagues (2016) make a critically important point when they note that the content of PD could be misdirected—that, is not focused on the actual teaching knowledge and skills that are needed to support student learning.[12] It is obviously most important that what teachers are taught re f ects the practices that can actually make a positive difference for student learning. That is, the content of professional development matters, along with its form.

Another crucial element is the knowledge that teachers bring to the PD experience—and whether it is sufficient to support their learning of particular pedagogical strategies. In one interesting case, where mathematics PD was conducted in a district that had very large numbers of uncredentialed teachers, researchers found positive effects on student learning only for those teachers who began with a higher level of content knowledge, signaling that the effectiveness of PD may depend in part on how solid a content foundation teachers have with which to absorb its lessons.[13] These and other considerations may influence the effectiveness of PD, even when it may share some of the features we identify here. Although it is beyond the scope of this paper to unpack why specific initiatives have proved less than fully successful, we identify barriers to the implementation of effective PD as identified by researchers later in this paper.

We aim to provide a research-based understanding of the kinds of PD that can lead to powerful professional learning, instructional improvement, and deeper student learning.

Goals and Outline of This Report

Our primary goal is to illuminate the features of PD that have been found to be effective, in hopes that this analysis can help inform policymakers and practitioners responsible for designing, planning, and implementing potentially productive opportunities for teacher learning.

We aim to provide practitioners, researchers, and policymakers with a research-based understanding of the kinds of PD that can lead to powerful professional learning, instructional improvement, and deeper student learning. By examining information about the nature of effective PD, policymakers and practitioners can begin to evaluate the needs of the systems in which teachers learn and do their work and consider how teachers' learning opportunities can be more effectively supported.

In the sections that follow, we first review the elements of effective PD initiatives identified through our review of recent literature, offering examples from specific studies and PD models. We then explore how the currently popular phenomenon of professional learning communities—often superficially implemented—can be effectively organized. Next, we provide an overview of the broader conditions that support or inhibit effective teacher PD in the United States, drawing on the broader PD literature. We conclude with considerations for policy and practice.

Thirty-one of the 35 studies we reviewed featured a specific content focus as part of the PD model. Among the PD models without a specific content focus, two focused on specific pedagogies that were not discipline specific,[29] and one study focused on supporting teachers in promoting inquiry-based learning and leveraging technology in support of standards-based instruction.[30] A final study provided insufficient description of the PD to determine whether or not the PD was content specific.[31]

One study of PD for upper elementary teachers, which focused on helping teachers analyze science teaching and improve pedagogy, illustrates job-embedded and content-focused PD. Roth et al. (2011) studied teachers participating in The Science Teachers Learning from Lesson Analysis (STeLLA) program.[32] The project focused on both science content and pedagogy using a video-based analysis-of-teaching PD model. The PD began with a three-week summer institute focused on science content taught by faculty at a local university. Teachers in the STeLLA program also engaged in video analysis of teaching during the summer institute. In follow-up sessions throughout the school year, teachers utilized Student Thinking and Science Content Storyline Lenses, creating PD that was both content specific and classroom based. The Student Thinking portion of the PD focused on understanding students' ideas for use in planning, teaching, and analysis of teaching—particularly in anticipating student thinking to assist teachers in responding to students' ideas and misunderstandings in productive ways. The Science Content Storyline portion of the PD focused on the sequencing of science ideas and how they are linked to help students construct a coherent "story" that makes sense to them. STeLLA teachers met in small groups facilitated by a program leader and discussed video cases of teaching that could include video(s) of one classroom, student
stud0033002les83 0 0 5.83 167.648739ude548 36002

program similarly found positive effects for students of participating teachers.[36] This study, similar to other studies in this review, suggests that PD that treats only content learning is not as effective as PD that links content learning to pedagogies supporting teachers' students and practice.[37]

Teacher professional learning that is context specific, job embedded, and content based is particularly important for addressing the diverse needs of students (and thus teachers) in differing settings. For example, in one study of PD for elementary science teachers in an urban school district, teachers of Latinx students learned science content as well as conversational Spanish and strategies for using culturally relevant pedagogies.[38] In another program targeting teachers of Latinx dual-language learners, monolingual teachers were provided with a range of instructional strategies to support children's primary language development in Spanish.[39] The key features of focusing on students' culture and language in these content- and context-specific PD models illustrate teacher professional learning opportunities designed for teaching content to specific student populations with targeted strategies to support their achievement.

Adults come to learning with experiences that should be utilized as resources for new learning.

Active Learning

The design of PD experiences must address *how* teachers learn, as well as *what* teachers learn. Trotter (2006) outlines several theories of learning and adult development and identifies themes that are relevant for designing teacher PD.

> Adults come to learning with experiences that should be utilized as resources for new learning.
> Adults should choose their learning opportunities based on interest and their own classroom experiences/needs.
> Reflection and inquiry should be central to learning and development.[40]

These themes provide a general framing that helps to explain why teacher PD that incorporates active learning experiences is effective in supporting student learning and growth. "Active learning" suggests moving away from traditional learning models that are generic and lecture based toward models that engage teachers directly in the practices they are learning and, preferably, are connected to teachers' classrooms and students. Active learning, in sharp contrast to sit-and-listen lectures, engages educators using authentic artifacts, interactive activities, and other strategies to provide deeply embedded, highly contextualized professional learning. Active learning is also an "umbrella" element that often incorporates the elements of collaboration, coaching, feedback, and reflection and the use of models and modeling.

Opportunities for "sense-making" activities are important.[41] Such activities often involve modeling the sought-after practices and constructing opportunities for teachers to analyze, try out, and reflect on the new strategies.[42] Active learning opportunities allow teachers to transform their teaching and not simply layer new strategies on top of the old, a hallmark of adult learning theory.[43]

Greenleaf et al. (2011) describe an active teacher professional learning model that improved student science learning.[44] California high school biology teachers participated in PD integrating academic literacy and biology instruction through a program called Reading Apprenticeship. The PD was inquiry based, subject focused, collaborative, and designed to address teachers' conceptual understandings as well as pedagogical content knowledge. Each session was designed to immerse the teachers in the types of learning activities and environments they would then create for their students. Teachers engaged in activities to simulate their own discipline expertise in relation to literacy, and they also engaged in analysis of texts to identify potential literacy challenges to learners.[45]

In addition, teachers analyzed student work, videotaped classroom lessons, and studied cases of student literacy learning designed to foster high expectations of student learning. Metacognitive routines such as think-alouds and reading logs for science investigations were used in PD sessions. Teachers also practiced classroom routines to build student engagement and student collaboration (e.g., "think-pair-share," jigsaws, text-based student discussion, and problem solving). An important part of the PD was a metacognitive reflection after each session that focused on the session's impact on teachers' learning and potential impact on their students' development.[46]

The program employed 10 sessions over the course of a year. An initial five-day institute took place the first summer of the study, followed by two follow-up days of PD during year 1 and a final three-day PD follow-up the summer after the academic year. During the study year, participants engaged in collaboration on a listserv that fostered the exchange of resources and ideas and was moderated by PD coaches. This multimodal, active learning PD model resulted in student achievement equivalent to a year's reading growth compared with students of teachers assigned to a control group. Students of treatment teachers also performed better than their counterparts in control classrooms on state assessments in English language arts and biology.[47]

The opportunity for teachers to engage in the same learning activities they are designing for their students is often utilized as a form of active learning.

The opportunity for teachers to engage in the same learning activities they are designing for their students is often utilized as a form of active learning. Several studies in this review highlighted PD programs that had teachers engage as learners through the use of curriculum and materials that they would then employ with their students. For instance, Buczynski and Hansen (2010) describe how 4th through 6th grade teachers had the opportunity to participate in "constructivist, hands-on experiences" through the use of science kits.[48] These were the same science kits that teachers would then go on to use in their classrooms with their students. Similarly, teachers in a study by Heller et al. (2012) completed the same scientific investigations they analyzed in written teaching cases.[49] In other studies, pedagogical and content experts would "teach" model lessons with teachers engaging as learners.[50] Additionally, two studies incorporated role-playing as a part of teachers "practicing" lessons with their peers to better understand students and their learning.[51]

Overall, 34 of the 35 studies incorporated some element of active learning in the design of the PD, while one study did not provide enough description of the PD model to ascertain whether active learning was present.

Collaboration

Such collaborative approaches have been found to be effective in promoting school change that extends beyond individual classrooms.[60] When whole grade levels, departments, or schools are involved, they provide a broader base of understanding and support at the school level. Teachers create a collective force for improved instruction and serve as support groups for each other's work on their practice. Collective work in trusting environments provides a basis for

Use of Models and Modeling

PD that utilizes models of effective practice has proven successful at promoting teacher learning and supporting student achievement. Curricular and instructional models and modeling of instruction help teachers to have a vision of practice on which to anchor their own learning and growth. The various kinds of modeling can include

video or written cases of teaching,
demonstration lessons,
unit or lesson plans,
observations of peers, and
curriculum materials including sample assessments and student work samples.

All 35 studies reviewed here included curricular models and/or modeling of effective instruction in the delivery of content and pedagogical learning for teachers. For example, Heller et al. (2012) conducted a randomized experimental design of three intervention groups and one control group to study the effects of PD on elementary students' learning in science.[68] The PD focused on pedagogical science content knowledge for elementary teachers, utilizing three different interventions, all of which proved successful in improving student achievement.

> Curricular and instructional models and modeling of instruction help teachers to have a vision of practice on which to anchor their own learning and growth.

One group of teachers analyzed written teaching cases, drawn from actual classrooms and written by teachers. Thus, the PD was an "analysis of practice" approach that incorporated models for student work analysis, student teacher dialogue analysis, and teacher thinking and behaviors. A second group analyzed their own students' work in relation to their teaching. Teachers in this intervention experienced carefully structured, collaborative analysis of their own students' work, which required that they teach a unit. Discussion protocols for the analysis of student work were employed that focused teachers' analysis on student understanding of content. These teachers took turns bringing in student work samples and formative assessment tasks that they analyzed collaboratively. Teachers also had access to a "task bank" of formative assessment model items they could use with their students. A third group utilized metacognitive analysis of their own learning experience in the form of reflective discussions about their own learning processes as they engaged in science content activities.

The course was designed to help teachers identify concepts they found challenging to learn, examine the logic behind their own common misunderstandings of the content, and analyze the roles of hands-on investigations, discourse, and inquiry in science learning. Expert staff developers delivered a series of three courses (the PD was delivered in 8 three-hour sessions, for a total of 24 contact hours with a facilitator).[69]

Findings of this study showed that students of teachers who participated in any of the PD opportunities had significantly greater learning gains on science tests than students whose teachers did not participate (with average gains of 19-22 percentage points compared to 13 points for control students). These effects were maintained a year later. Student justification of correct answers in year 1 of the study showed significant improvement from pre- to post-test for those students whose

Feedback and Reflection

Feedback and reflection are two other powerful tools found in effective PD; they are often employed during mentoring and coaching but are not limited to these spaces. As noted earlier, feedback and reflection are critical components of adult learning theory. Professional development models associated with gains in student learning frequently provide built-in time for teachers to think about, receive input on, and make changes to their practice by providing intentional time for feedback and/or reflection. While feedback and reflection are two distinct practices, they work together to help teachers move thoughtfully toward the expert visions of practice that they may have learned about or seen modeled during PD.

Another common strategy is to engage teachers in multiple sessions of a similar structure, often over a semester or school year, to promote meaningful professional learning.[104] The program described by Heller et al. (2012) included 8 three-hour sessions in which certain ideas about science instruction were taught and discussed, while teachers also engaged in related activities in their classrooms between the sessions. The model studied by Doppelt et al. (2009) was delivered in five workshops, each lasting four hours.[105] Between workshop classes, the teachers implemented related activities, which were grist for their reflections and discussion in the workshops. Although

Realizing the Promise of Professional Learning Communities

This review has so far offered rich descriptions of professional development models that have incorporated various elements of effective PD. One currently popular model is the use of Professional Learning Communities (PLCs). While many professional learning community efforts

Learning From Professional Communities Beyond the School

Positive effects of professional communities that operate beyond the school level have also been documented by a number of researchers.[114] These are often organized via networks that connect teachers around subject matter or other shared educational concerns. Lieberman and Wood (2002) reported on the work of the National Writing Project (NWP), one of the most successful teacher networks, to understand how teacher learning in a community can be a source of efficacy and confidence in the process of adopting new practices.[115] The NWP, initially called the Bay Area Writing Project, began in 1973 as a partnership in California between the University of California, Berkeley, and local school districts. It has grown to more than 185 sites in all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.[116] The heart of the model is the local school-university partnerships, which operate as autonomous sites to support context-specific strengths and meet context-specific challenges. "These sites are designed to be robust professional and social communities that occupy an intermediary or 'third space,' neither wholly of the university nor wholly of the school districts."[117]

Despite the autonomy of the local sites, there are common design features and core principles

cZ0‘CRpXUFHGWRSUDF

E□ective Professional Development in Practice: National Writing Project's College-Ready Writers Program

The College-Ready Writers Program (CRWP) is a National Writing Project program that focuses

4. Few schools, districts, or state education agencies have created good systems of tracking PD, let alone systems for analyzing the quality and impact of PD. Without a sense of what is working and why, it is hard to adopt and implement professional learning for teachers that is evidence based and designed to address potential obstacles.[134]

Even in the case of well-designed PD, these obstacles can impede the effectiveness of professional learning and hinder its impact on student learning and achievement. The challenges with implementing and scaling evidence-based practices underscore that translating promising PD research into practice remains one area ripe for improvement.

Conclusions and Policy Implications

Professional development is an important strategy for ensuring that educators are equipped to support deep and complex student learning in their classrooms. However, research shows great variation in the extent to which PD programs accomplish this goal. This paper has examined recent studies of successful PD models that report student learning gains. We identify seven common design elements of these effective PD approaches.

1. They are .
2. They incorporate .
3. They engage teachers in .
4. They use and/or modeling.
5. They provide .
6. They include time for .
7. They are of .

Across the reviewed studies, these elements have been combined in a variety of ways to support teachers' professional learning. Indeed, none of the successful programs featured attributes in isolation: As Hargreaves and Fullan (2012) note, the combination of these elements creates a collaborative culture that results in a form of collective professional capital that leverages much more productive, widespread improvement in an organization than would be possible if teachers worked alone in egg-crate classrooms.[135] Regardless of the specific model employed, PD should be well designed, incorporating elements of effective PD, as we have described. It should also be linked to identified teacher needs, should ensure that teachers have a say in the type of learning they require to best support their students, and should be regularly evaluated so that quality can be continually improved.

Implications for Policy

Supporting and incentivizing the kind of evidence-based PD we have reviewed here could be facilitated by changes in policy. For example:

> Policymakers could to guide the design, evaluation, and funding of professional learning provided to educators. These standards might reflect the features of effective professional learning outlined in this report as well as standards for implementation.[136]

> Policymakers and administrators could to increase opportunities for professional learning and collaboration, including participation in professional learning communities, peer coaching and observations across classrooms, and collaborative planning.

> States, districts, and schools could regularly using data from staff surveys to identify areas of professional learning most needed and desired by educators. Data from these sources can help ensure that professional learning is not disconnected from practice and supports the areas of knowledge and skills educators want to develop.

State and district administrators could
to support learning in their particular area(s) of expertise for other educators.

States and districts can
, such as efforts to implement new learning standards, use student data to inform instruction, improve student literacy, increase student access to advanced coursework, and create a positive and inclusive learning environment.

States and districts can
, using funding available under Titles II and IV of ESSA to address the needs of rural communities and provide opportunities for intradistrict and intraschool collaboration.

Policymakers can for learning opportunities that include sustained engagement in collaboration, mentoring, and coaching, as well as institutes, workshops, and seminars.

Implications for Implementation and Practice

At the same time, well-designed programs must also be implemented well to be effective. Even the best designed PD may fail to produce desired outcomes if it is poorly implemented due to barriers such as

- inadequate resources, including needed curriculum materials;
- lack of shared vision about what high-quality instruction entails;
- lack of time for planning and implementing new instructional approaches;
- con f icting requirements, such as scripted curriculum or pacing guides; and
- lack of adequate foundational knowledge on the part of teachers.

Common obstacles to PD should be anticipated and planned for during both the design and implementation phases of PD. Implementing PD well also requires responsiveness to the needs of educators and learners and to the contexts in which teaching and learning will take place.

In the end, well-designed and implemented PD should be considered an essential component of a comprehensive system of teaching and learning that supports students to develop the knowledge, skills, and competencies they need to thrive in the 21st century. To ensure a coherent system that supports teachers across the entire professional continuum, professional learning should link to their experiences in preparation and induction, as well as to teaching standards and evaluation. It should also bridge to leadership opportunities to ensure a comprehensive system focused on the growth and development of teachers.

Appendix A: Methodology

regarding the effectiveness of PD, so are retained in Appendix B and referred to where relevant in

Appendix B: Summary of Studies Reviewed for This Report

ES is used to denote effect sizes.

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Akiba, M. & Liang, G. (2016). E□ects of teacher professional learning activities on student achievement growth. ***The Journal of Educational Research, 109*****(1), 99–110.** **Description:** Researchers analyzed three years of results from the Teachers' Opportunity to Learn (TOTL) survey of middle school mathematics teachers in Missouri. Analysis focuses on what types of professional development, as defined by the survey (standard professional development, teacher collaboration,	

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Allen, J. P., Hafen, C. A., Gregory, A. C., Mikami, A. Y., & Pianta, R. (2015). Enhancing secondary school instruction and student achievement: Replication and extension of the My Teaching Partner–Secondary intervention. ***Journal of Research on Educational E ectiveness 8*****(4): 475–489.** **Description:** Teachers participated in My Teaching Partner–Secondary, a web-mediated coaching program to improve teacher-student interactions in the classroom. Teachers participated in an initial half-day training with master teachers from the research team who would go on to provide remote coaching for the duration of the program. This initial workshop focused on the dimensions of high-quality student-teacher interactions, such as teacher sensitivity and regard for student perspectives, and included videos of exemplary practice. Over the next two academic years, teachers engaged in 12 remote coaching cycles focused on student-teacher relationships, classroom organization, and instructional support. In each coaching cycle, teachers shared a video of a typical lesson with their coach, who chose short segments of the lesson to highlight for analysis and discussion. Coaches shared these segments with teachers, who were asked to examine their own practice, student responses to their practice, and the relationship between teacher practice and student reactions. This reflection was followed by a 20- to 30-minute phone conference focused on instructional strategies to strengthen interactions with students. This coaching cycle occurred every 6 weeks. The 2-year program concluded with a final booster workshop.	**Methodology:** Stratified randomized controlled trial • *n*= 86 secondary school teachers and 1,194 secondary students in a diverse urban school district. • Student achievement measured by Virginia state standardized tests in the subject areas taught by the participating teachers. **Findings:** At the end of the two-year program, students whose teachers participated demonstrated gains in achievement equivalent to an average increase from the 50th to 59th percentile relative to students whose teachers had not participated (ES = 0.48).
Antoniou, P. & Kyriakides, L. (2013). A dynamic integrated approach to teacher professional development: Impact and sustainability of the e ects on improving teacher behavior and student outcomes. ***Teaching and Teacher Education, 29*****, 1–12.** **Description:** Teachers participated in PD using either the Dynamic Integrated Approach (DIA) or the Holistic Approach (HA). Using the DIA, teachers' skills were evaluated and assigned to one of five developmental stages, with each stage focusing on increasingly complex teaching skills. The Holistic Approach examines attitudes, beliefs, and practices not limited to stages and skills. Teachers attended nine monthly sessions throughout the school year. The DIA group sessions consisted of assigning teachers' developmental stages and collaborating and creating individual action plans. Between each PD session, teachers implemented their plans in their classrooms, received feedback, and revised their plans. Teachers in the HA group reflected and discussed a problem based on attitude, beliefs, and practice. The remaining sessions were used to create, discuss implementation, and adjust an action plan with colleagues. Each monthly session lasted 3-4 hours in duration totaling 27-36 hours. Both groups completed a total of 88.5 hours of PD.	**Methodology:** Randomized controlled trial • *n*=123 3rd- to 6th-grade teachers in Cyprus schools and 131 students • Criterion-reference math tests **Findings:** Overall, the achievement of students whose teachers employed DIA was 0.34 standard deviations higher than those in the HA group. Students of teachers at stages 1 and 2 scored lower (-0.52 and -0.24 standard deviations respectively) than those of teachers at stage 3. Students of teachers at stage 4 had the highest achievement gains. Students of teachers in stage 4 of the DIA group scored 0.32 standard deviations higher than students of teachers at stage 3.

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice; uncovering connections. ***Teacher and Teacher Education, 26,*** **599–607.** **Description:** Teacher PD focused on integrated, inquiry-based instruction in elementary classrooms. An Inquiry Learning Partnership (ILP) was formed between two urban school districts, a science museum, and a university to develop the professional development program for 4th- to 6th-grade trade teachers. The co-designed PD consisted of standards-based content and inquiry-based strategies. PD consisted of lectures on subject matter by university professors paired with constructivist, hands-on experiences for teachers with science kits and demonstration of inquiry practices. Science content was taught by university faculty, while pedagogy sessions were led by the ILP director and district resource teachers. Pedagogy session topics were identified as formative assessment, use of student science notebooks, unpacking standards, teaching English learners, adapting curriculum, best practices, and addressing the achievement gap. PD was administered during a 35-hour, weeklong summer institute. In addition, teachers attended at least seven of 29 available seven-hour Saturday content sessions over the course of an academic year.	**Methodologyi- experementuy witinf anderatory casl stu** **9 n** **9 Student(ac).hievementmlea(ur)1.dt byscodres on2005, and2006 C** **tandard Te(t)-9 (p (3)fprm (gr)1 (ade5, andfpr)19.1 (m lo c)-6 (le a)2 (s)** **2%g idfprm teachers hon dde notpaer-339 stiipmatn id P. In(t)5 (hes** **u at le1.11 arnersdM prhod Rye-tQer**

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Finkelstein, N., Hanson, T., Huang, C. W., Hirschman, B., & Huang, M. (2010). E□ects of problem based economics on high school economics instruction. Final report. ***National Center for Education Evaluation and Regional Assistance, NCEE 2010–4002.*** **Description:** PD focused on the Problem Based Economics curriculum developed by the Buck Institute for Education on 12th-graders' content knowledge measured by the Test of Economic Literacy and a performance task as opposed to a traditional lecture and textbook format. The problem-based approach allows students to reason through and solve a real-world problem through inquiry-based pedagogy. Control group and intervention teachers taught two consecutive semesters (fall and spring) of economics. Intervention teachers taught the Problem Based Economics curriculum, while the control group taught the typical course. Only student data for the spring were included in the analysis. Intervention teachers taught five of the nine modules in the problem-based curriculum. Intervention teachers participated in a five-day professional development workshop to become familiar with the module and pedagogical strategies. They were trained by current and former economics teachers. On four occasions throughout the semester, once at the beginning and throughout the module completion, teachers participated in a group conference call with developers and the study team to discuss progress and challenges and get feedback. Teachers also had the ability to call and email Buck Institute staff throughout the implementation. The PD took place for one academic school year—a five-day training and periodic check-ins throughout the school year.	**Methodology:** Within-school randomized controlled trial • *n*=64 11th- and 12th-grade economics teachers and 4,350 students in Arizona and California • Student outcomes measured by Test of Economic Literacy (TEL) and a performance task assessment **Findings:** Teachers who participated in the PD and had support in Problem Based Economics had students who scored 0.27 standard deviations higher on the TEL (on average got 2.6 test items correct) than teachers who had not participated in the PD.
Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. ***Journal of Research on Educational E ectiveness, 1-26.*** **Description:**	

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., & Schneider, S. A. (2011). Integrating literacy and science in biology: teaching and learning impacts of reading apprenticeship professional development. ***American Educational Research Journal, 48*****(3), 647–717.** **Description:** High school biology teachers participated in professional development integrating academic literacy and biology instruction through Reading Apprenticeship. The program was inquiry-based, subject-focused, collaborative, and designed to address teachers' conceptual understandings as well as pedagogical content knowledge. The sessions were designed to immerse teachers in the types of learning activities and environments they would then create for their students. They engaged in activities to simulate their own discipline expertise in relation to literacy, and they also engaged in analysis of texts to identify potential literacy challenges to learners. In addition, teachers analyzed student work, videotaped classroom lessons, and studied cases of student literacy learning designed to foster high expectations of student learning. Metacognitive routines such as think-alouds and reading logs for science investigations were also used in professional development sessions. In the sessions, teachers practiced classroom routines to build student engagement), student collaboration (e.g., think-pair-share, jigsaws, and text-based student discussion and problem- solving (e.g., text annotation). Metacognitive reflection after each session focused on the impact of these sessions on teachers' learning and potential impact on their students' development. The 10 professional development sessions took place over the course of a year. An initial five-day institute took place the first summer of the study. This was followed by two follow-up days of professional development during year 1, and a final three-day follow-up occurred the summer following the academic year. During the study year, participants engaged in collaboration on a listserv moderated by professional development coaches, including the exchange of resources.	**Methodology:** Group-randomized experimental study utilizing hierarchical linear modeling • *n*=105 California high school biology teachers in underserved public high schools • Student learning measured using California states tests of English language arts, reading comprehension, and biology **Findings:** Students in treatment classrooms performed better than controls on state standardized assessments in English language arts (ES=0.23), reading comprehension (ES=0.24), and biology (ES=0.28). Treatment classes performed about a year ahead of the control classes at the end of the study. Effect sizes for white students in treatment classrooms ranged from 0.33 to 0.40 and for English learners from 0.18 to 0.23. Positive impacts were also found on ELA and biology test scores of Latinx students, although these were not statistically significant. No significant test score differences were found for African American students across classroom types. Test scores for reading comprehension and biology were higher in intervention schools than in control schools for both males and female students.

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Heller, J. I., Daehler, K .R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Di□erential e□ects of three professional development models on teacher knowledge and student achievement in elementary science. ***Journal of Research in Science Teaching, Vol. 49, No. 3, pp. 333–362.*** **Description:** This PD focused on pedagogical science content knowledge for elementary teachers, utilizing three different interventions. One group of teachers analyzed prestructured written teaching cases. These cases were drawn from actual classrooms and written by teachers. Thus, it was an analysis of practice approach, which incorporated student work analysis, student teacher dialogue analysis, and teacher thinking and behaviors. Teachers also engaged in the same scientific investigations written about in the cases during their PD sessions. Embedded in this PD was identifying the logic behind common scientific misunderstandings, analyzing teachers' instructional choices, and considering teaching implications for their own students. A second group analyzed their own student work in relation to their teaching. Teachers in this intervention experienced carefully structured, collaborative analysis of their own students' work, which was derived from a common unit they taught. Discussion protocols for the analysis of student work were employed, which focused teachers' analysis on student understanding of content. In addition, these sessions also focused on the analysis of tasks to identify characteristics that support formative assessments t(udent t)5.1 (hi)9 (in)1. TDA (hi)9 (rlo)18d (oup of t)1u(if)-23 (z)14 (in t)5 (hme15 (a)2 (s)cic be)nive analysis of their	

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Johnson, C. C. & Fargo, J. D. (2014). A study of the impact of transformative professional development on Hispanic student performance on state mandated assessments of science in elementary school. *Journal of Elementary Science Teacher Education 25:* 845–859. **Description:** Elementary school science teachers participated in a professional development program to improve science instruction and facilitate culturally relevant pedagogy. The two-year program began with a two-week summer workshop that included graduate-level coursework on teaching elementary science, as well as orientation to a new science curriculum and culturally relevant pedagogy. During the second summer, the workshop focused on teaching elementary science and learning conversational Spanish. Professional development was reinforced through occasional release days and monthly grade-level workshops with professional learning communities. Over 2 years, the program provided 224 hours of professional development.	**Methodology:** Three-year case study drawn from a cluster randomized, controlled trial • *n*=21 teachers in two elementary schools in a large urban school district in a southwestern state • Student science achievement was measured by performance on a state-mandated science assessment. **Findings:** Students attending the school whose teachers participated in the PD program demonstrated significantly larger improvements in science achievement over time relative to students who attended the school with business-as-usual PD for their teachers.
Johnson, C. C. & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29. **Description:** Middle school science teachers working in an urban school district participated in a professional development program to strengthen standards-based instruction and foster culturally responsive teaching. The hands-on, whole-school program began with a two-week summer institute designed to foster relationship-building among teachers and introduce a new science curriculum and culturally responsive teacher strategies. Throughout the first year of the program, teachers attended monthly workshop days to refine the curriculum to better meet the needs of their students and undertook peer observations, providing positive and constructive feedback to colleagues. In the second year of the program, teachers attended a three-day summer session and additional monthly release days, and conducted home visits to deepen relationships with students and families. In total, the program offered nearly 200 hours of professional development, with 120 hours in the first year and 77 hours in the second.	**Methodology:** Two-year quasi-experimental study • *n*=16 middle school science teachers from four schools in one urban district • Student science achievement was measured using specially designed assessments. **Findings:** Students of teachers participating in the PD demonstrated significantly larger growth in science achievement than students at control schools in the second year of the program, with gains twice as large as those of students in the control schools.

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Kleickmann, T., Trobst, S., Jonen, A., Vehmeyer, J., & Moller, K. (2016). The e□ects of expert sca□olding in elementary science professional development on teachers' beliefs and motivations, instructional practices, and student achievement. ***Journal of Educational Psychology, 108*****(1) 21–42.** **Description:** PD focused on implementing a social constructivist approach to elementary science teaching through educational curriculum materials (ECM). Three groups of teachers participated in PD, each group with a different level of scaffolding (support for their learning through ECM). One group used the ECM materials with no expert scaffolding. Two other groups received 16 all-day workshops of PD to supplement the use of ECM. The first six (38 hours) focused specifically on floating and sinking. The 10 additional workshops (62 hours) focused on the other 10 topics. The focus of the workshops was to develop content and pedagogy. The "high scaffolding" group of teachers engaged in active learning activities such as scientific investigations, providing counter examples, developing analogies, and engaging in discussions. In general, the PD the teachers received mimicked the process by which they were to guide their elementary students. Teachers were also prompted to reflect on their own learning processes and to consider their own naïve science conceptions to help them understand the need to construct learning to fit students' existing schema. In addition, expert helped teachers to understand sequencing of science concepts to facilitate student learning. In contrast, the "low scaffolding" group of teachers received little of this support. Instead, the expert PD coach demonstrated a series of lessons on floating and sinking in a 3rd-grade classroom without scaffolding teachers' content and pedagogical knowledge. Teachers observed these lessons and conducted pre- and post-interviews with students. They were encouraged to discuss their observations in relation to the student interviews. The PD spanned approximately five months, with scaffolded groups receiving an additional 100 hours of PD during this time.	**Methodology:** Two-year quasi-experimental study • *n*=73 elementary science teachers and 1,039 3rd and 4th-grade students • Student achievement was measured through an assessment of students' conceptual understanding of floating and sinking **Findings:** Students taught by teachers who received "high scaffolding" exhibited significantly higher achievement than did students taught by "low scaffolding" teachers (ES=.45). Student achievement for both "high scaffolding" and "low scaffolding" teachers significantly surpassed achievement in classes taught by teachers with no scaffolding (ES=.55).

Study Methodology and Findings Related to Student Outcomes		
Study and Professional Development Description		

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
McGill-Franzen, A., Allington, R. L., Yokoi, L., & Brooks, G. (1999). Putting books in the classroom seems necessary but not su□cient. *The Journal of Education Research 93*(2):67–74. **Description:** Kindergarten teachers participated in a training program to enhance their use of books in classroom lessons. Training sessions spanned topics such as classroom organization, read-aloud techniques, story-related lesson plans, and play-based literacy activities. Participating teachers also received a large supply of books for classroom libraries and students' home libraries. Overall, teachers participated in 30 hours of training, including three daylong workshops and seven shorter meetings.	**Methodology:** Stratified randomized controlled trial • *n*=18 kindergarten teachers and 377 children from six schools in a single large eastern urban school district • Student outcomes measured using two widely used early literacy instruments **Fom see2 to (ic(lon)6896 -A(s)23 9)23 aricipating (e)3 (ac)8 (her)-8.7.1 (ar)-33 (tle)-7 (s)-16 (sons**

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Newman, D., Finney, P. B., Bell, S., Turner, H., Jaciw, A., Zacamy, J. L., & Gould, L. F. (2012). ***Evaluation of the E ectiveness of the Alabama Math, Science, and***	

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Polly, D., McGee, J., Wang, C., Martin, C., Lambert, R., & Pugalee, D. K. (2015) Linking professional development, teacher outcomes, and student achievement: The case of a learner-centered mathematics program for elementary school teachers. *International Journal of Education Research* 72, 26–37. **Description:** Elementary math teachers engaged in a PD program to bolster standards-based elementary math instruction. The program was designed to be learner-centered, offering active learning opportunities that are collaborative, owned by teachers, supportive of changes in classroom practice, and that foster pedagogical and content knowledge. Teachers participated in a number of activities, including a summer workshop, follow-up workshops during the academic year, and classroom-embedded professional development activities. All activities were coordinated by a project team that included a mathematics professor, mathematics education professors, and school leaders. The program provided approximately 80 hours of professional development over 10 months.	**Methodology:** Three-year nonexperimental study • *n*=291 elementary mathematics teachers from two school districts: one large urban district and a nearby suburban district • Student outcomes were measured using curriculum-based assessments. **Findings:**

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I. Z. (2011). Videobased lesson analysis: E□ective science PD for teacher and student learning. ***Journal on Research in Science Teaching, 48*****(2),117–148.** The Science Teachers Learning through Lesson Analysis (STeLLA) PD was a videobased analysis of a practice program for upper elementary teachers designed to help them analyze science teaching and learning to improve pedagogy. Two groups participated in the study. Both groups received the same science content instruction from university scientists during a three-week summer institute. STeLLA participants also engaged in video analysis of teaching during the summer institute and in follow-up sessions across the school year utilizing the Student Thinking and Science Content Storyline Lenses. The Student Thinking portion of PD focused on understanding students' ideas for use in planning, teaching, and analysis of teaching, particularly in anticipating student thinking to assist teachers in responding to students' ideas and misunderstandings in productive ways. The Science Content Storyline portion of the PD focused on the sequencing of science ideas to help students construct a coherent "story" that makes sense to them. STeLLA teachers met in small groups facilitated by STeLLA program leaders and discussed video cases of teaching that could include video(s) of one classroom, student and teacher interviews, teacher materials, and student work samples. STeLLA teachers also taught a set of four to six model lessons themselves and analyzed their teaching using a structured protocol. Purposes of these lessons were identified as: 1) modeling and scaffolding of the two lenses; 2) clarify science content understandings; and 3) provide common curriculum for lesson analysis work. Half of a study group would teach the lessons and the entire group would collaboratively analyze the teaching and student work, and then revise the lessons for the other half to use. The roles would then switch and the second half of the group would teach the lessons that would be used for analysis. The analysis was highly scaffolded by the PD facilitators. STeLLA groups met for 58 hours of analysis across the school year, in addition to 44 hours during the three-week summer session for a total of 102 hours. Content-only teachers received just the 44 hours of PD.	**Methodology:** Quasi-experimental comparison group study design • *n*=48 urban California upper elementary teachers of 1,490 students • Student achievement was measured by pre- and post-tests of student content knowledge. **Findings:** STeLLA teachers' students showed greater gains than non-STeLLA teachers' students. For a typical student taught by a STeLLA teacher, higher average achievement was associated with: • Teachers' science content knowledge (ES =.20) • Teachers' ability to analyze science teaching about student thinking (ES =.18) • Teachers' classroom use of Science Content Storyline strategy; selecting and using content representations matched to the main learning goal (ES=.32)

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Saxe, G. B,, Gearhart, M., & Nasir, N. S. (2001). Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support. ***Journal of Mathematics Teacher Education 4:*** **55–79.** **Description:** Upper elementary school teachers participated in a reform-oriented professional development program designed to enhance student understanding of fractions. The program began with a five-day summer institute, followed by biweekly meetings for the remainder of the school year. Program meetings targeted teachers' own mathematical content knowledge, their understanding of students' mathematical thinking and motivation, and their competence in the use of integrated assessments. The meetings utilized individual and collaborative work, and active-learning strategies such as role-playing. Teachers participating in the program were also provided with two lessons from a reform mathematics curriculum to implement in their classrooms.	**Methodology:** Quasi-experimental design utilizing ANCOVA analyses • *n*=23 upper elementary school teachers • Student knowledge of fractions was measured using a specially designed test with both conceptual and computational items. **Findings:** Teacher participation in the professional development program was associated with higher student achievement on the conceptual portion of the fractions test. There was no difference on the computational portion of the fractions test.
Shaha, S. H. & Ellsworth, H. (2013). Predictors of success for professional development: Linking student achievement to school and educator successes through on-demand, online professional learning. ***Journal of Instructional Psychology 40(*****1): 19–26.** **Description:** Educators participated in online, on-demand professional development through a web-based commercial product featuring teacher resources such as videos and online forums. In each participating school, teachers averaged at least 90 minutes of video viewing on the PD platform, though teachers in higher engagement schools averaged six hours of viewing and teachers in lower engagement schools averaged three hours. Through the platform, teachers had the opportunity to answer follow-up and reflection questions about content, create focus objectives, and join interactive user forums and communities.	**Methodology:** Two-year quasi-experimental design • *n*=734 schools in 39 states • Student achievement was measured by students achieving proficient or advanced ratings on standardized math and reading tests. **Findings:** Students at schools with higher average engagement with the PD program improved reading achievement at four times the rate of students at schools with lower average engagement and improved math achievement at 30 times the rate of students at low-engagement schools.

Study and Professional Development Description	Study Methodology and Findings Related to Student Outcomes
Taylor, J. A., Roth, K., Wilson, C., Stuhlsatz, M., & Tipton, E. (2017). The e□ect of an analysis-of-practice, videocase-based, teacher professional development program on elementary students' science achievement. ***Journal of Research on Educational E ectiveness, 10***	

Appendix C:
Elements of E□ective Professional Development by Study

"NS" indicates not specifed in study.

Seven Elements of E□ective Professional Development

1. They are content focused.
2. They incorporate active learning strategies.
3. They engage teachers in collaboration.
4. They use models and/or modeling.
5. They provide coaching and expert support.
6. They include opportunities for feedback and refection.
7. They are of sustained duration.

Study	Active Learning	Coaching/Expert Support	Collaborative	Content-Focused	Feedback	Reflection	Models/ Modeling	Sustained Duration
Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). *An interaction-based approach to enhancing secondary school instruction and student achievement.*	X	X	X		X	X	X	X
Allen, J.P., Hafen, C.A., Gregory, A.C., Mikami, A.Y. & Pianta, R. (2015). *Enhancing secondary school instruction and student achievement: Replication and extension of the My Teaching Partner-Secondary intervention.*	X	X	X		X	X	X	X
Antoniou, P. and Kyriakides, L. (2013). *A Dynamic Integrated Approach to teacher professional development: Impact and sustainability of the effects on improving teacher behavior and student outcomes.*	X	X	X	X	X	X	X	NS

Study	Active Learning	Coaching/Expert Support	Collaborative	Content-Focused	Feedback	Reflection	Models/ Modeling	Sustained Duration
Carpenter, T.P., Fennema, E., Peterson, P.L., Chiang, C., & Loef, M. (1989). *Using knowledge of children's mathematics thinking in classroom teaching: An experimental study.*	X	X	X	X	X	X	X	X
Doppelt, Y., Schunn C.D., Silk, E.M., Mehalik, M.M., Reynolds, B. & Ward, E. (2009). *Evaluating the impact of facilitated learning community approach to professional development on teacher practice and student achievement.*	X	X	X	X	X	X	X	X
Finkelstein, N., Hanson, T., Huang, C. W., Hirschman, B., & Huang, M. (2010). *Effects of problem based economics on high school economics instruction.*	X	X	X	X	X	X	X	X
Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2015). *Impact of the National Writing Project's College-Ready Writers program in high-need rural districts.*	X	X	X	X	X	X	X	X
Gersten, R. Dimino, J., Jayanthi, M., Kim, J. S., & Santoro, L.E. (2010). *Teacher study group: Impact of the professional development model on reading instruction and student outcomes in first grade classrooms.*	X	X	X	X	X	X	X	X
Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A. (2011). *Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development.*	X	X	X	X	NS	X	X	X
Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). *Differential effects of three professional development models on teacher knowledge and student achievement in elementary science.*	X	X	X	X	X	X	X	X
Johnson, C. C. & Fargo, J. D. (2014). *A study of the impact of transformative professional development on Hispanic student performance on state mandated assessments of science in elementary school.*	X	X	X	X	X	X	X	X

Study	Active Learning	Coaching/Expert Support	Collaborative	Content-Focused	Feedback	Reflection	Models/ Modeling	Sustained Duration
Johnson, C. C., & Fargo, J. D. (2010). *Urban school reform enabled by transformative professional development: Impact on teacher-mediated Quantum-focused K-5 (.)10(hooS6 1f[U)9(0)-5.1 (,3 1 Tf[B)-4f[U)9(Sc3c)]T2(g)16(4, &R)Tf[U)9(0)Ta*								

Study	Active Learning	Coaching/Expert Support	Collaborative	Content-Focused	Feedback	Reflection	Models/ Modeling	Sustained Duration
May, H.; Sirinides, P. M., Gray, A., and Goldsworthy, H. (2016). *Reading Recovery: An evaluation of the four-Year i3 scale-up.*	X	X	X	X	X	X	X	X
McGill-Franzen, A., Allington, R. L., Yokoi, L., & Brooks, G. (1999). *Putting books in the classroom seems necessary but not sufficient.*	NS	NS	NS	X	NS	NS	X	X
Meissel, K., Parr, J. M., Timperley, H. S. (2016). *Can professional development of teachers reduce disparity in student achievement?*	X	X	X	X	X	X	X	NS
Meyers, C. V., Molefe, A., Brandt, W. C., Zhu, B., & Dhillon, S. (2016). *Impact Results of the eMINTS Professional Development Validation Study.*	X	X	X		X	X	X	X
Newman, D., Finney, P. B., Bell, S., Turner, H., Jaciw, A., Zacamy, J. L., & Gould, L. F. (2012). *Evaluation of the effectiveness of the Alabam IMion of tll*								
the Alasas								

Study	Active Learning	Coaching/Expert Support	Collaborative	Content-Focused	Feedback	Reflection	Models/ Modeling	Sustained Duration
Sample McMeeking, L. B., Orsi, R., & Cobb, R. B. (2012). *Effects of a teacher professional development program on the mathematics achievement of middle school students.*	X	X	NS	X	NS	X	X	X
Saxe, G. B., Gearhart, M., & Nasir, N. S. (2001). *Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support.*	X	X	X	X	NS	X	X	X
Shaha, S. H. & Ellsworth, H. (2013). *Predictors of success for professional development: Linking student achievement to school and educator successes through on-demand, online professional learning.*	X		X	NS	NS	X	X	NS
Taylor, J. A., Roth, K., Wilson, C., Stuhlsatz, M, & Tipton, E. (2017). *The Effect of an Analysis-of-Practice, Videocase-Based, Teacher Professional Development Program on Elementary Students' Science Achievement.*	X	X	X	X	X	X	X	X
Total:	34 (1 NS)	30 (4 NS)	32 (3 NS)	31 (1 NS)	24 (11 NS)	34 (1 NS)	35	3 (4 NS)

Endnotes

1. Hill, H. C., Beisiegel, M., & Jacob, R. (2013). Professional development research: Consensus, crossroads, and challenges. *Educational Researcher, 42*(9), 476–487.
2. TNTP. (2015). *The mirage: Confronting the hard truth about our quest for teacher development*. Brooklyn, NY: TNTP.
3. Easton, L. B. (2008). From professional development to professional learning. *Phi Delta Kappan, 89*(10), 755–761; Fullan, M. (2007). *The new meaning of educational change, 4th edition.* New York City, NY: Teachers College, Columbia University.
4. Fullan, M. (2007). *The new meaning of educational change, 4th edition*, 35. New York City, NY: Teachers College, Columbia University.
5. Wei, R. C., Darling-Hammond, L., & Adamson, F. (2010). *Professional development in the United States: Trends and challenges* (Vol. 28). Dallas, TX: National Staff Development Council.
6. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599–607; Johnson, C. & Adamson, 47 *Teaching and Teacher Education, 26*6a

13. Santagata, R., Kersting, N., Givvin, K. B., & Stigler, J. W. (2011). Problem implementation as a lever for change: An experimental study of the effects of a professional development program on students' mathematics learning. *Journal of Research on Educational Effectiveness, 4*(1), 1–24.

14. Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession*. Washington, DC: National Staff Development Council; Stein, M. K., Smith, M. S., & Silver, E. (1999). The development of professional developers: Learning to assist teachers in new settings in new ways.

Goldsworthy, H. (2016). *Reading Recovery: An Evaluation of the Four-Year i3 Scale-Up*. Philadelphia, PA: Consortium for Policy Research in Education. http://repository.upenn.edu/cgi/viewcontent.cgi?article=1089&context=cpre_researchreports (accessed 11/17/2016); Meissel, K., Parr, J. M., & Timperley, H.S. (2016). Can professional development of teachers reduce disparity in student achievement? *Teaching and Teacher Education, 58*, 163–173; Polly, D., McGee, J., Wang, C., Martin, C., Lambert, R., & Pugalee, D.K. (2015). Linking professional development, teacher outcomes, and student achievement: The case of a learner-centered mathematics program for elementary school teachers. *International Journal of Education Research, 72*, 26–37.

28. Penuel, W. R., Gallagher, L. P., & Moorthy, S. (2011). Preparing teachers to design sequences of instruction in Earth systems science: A Comparison of three professional development programs. *American Educational Research Journal, 48*(4), 996–1025.

29. Allen, J. P., Hafen, C. A., Gregory, A. C., Mikami, A. Y., & Pianta, R. (2015). Enhancing secondary school instruction and student achievement: Replication and extension of the My Teaching Partner-Secondary intervention. *Journal of Research on Educational Effectiveness, 8*

Journal, 26(4), 499—531; Cohen, D. K., & Hill, H. C. (2001). *Learning policy.* New Haven, CT: Yale University Press; Garet, M., Porter, A., Desimone, L., Birman, B., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945; Desimone, L., Porter, A., Garet, M., Yoon, K., & Birman, B. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Education Evaluation and Policy Analysis, 24*(2), 81–112; Penuel, W., Fishman, B., Yamaguchi, R., & Gallagher, L. (2007). What makes professional development effective? Strategies that foster curriculum implementation. *American Educational Research Journal, 44*(4), 921–958; Saxe, G. B., Gearhart, M., & Nasir, N. S. (2001). Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support. *Journal of Mathematics Teacher Education, 4*(1), 55–79; Supovitz, J. A., Mayer, D. P., & Kahle, J. B. (2000). Promoting inquiry based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy 14*(3), 331–356.

43. Trotter, Y. D. (2006). Adult learning theories: Impacting professional development programs. *Delta Kappa Gamma Bulletin, 72*(2), 8.

44. Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A., Madden, S., & Jones, B. (2011). Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development. *American Educational Research Journal, 48*(3), 647–717.

45. Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A., Madden, S., & Jones, B. (2011). Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development. *American Educational Research Journal, 48*(3), 647–717.

46. Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A., Madden, S., & Jones, B. (2011). Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development. *American Educational Research Journal, 48*(3), 647–717.

47. Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A., Madden, S., & Jones, B. (2011). Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development. *American Educational Research Journal, 48*(3), 647–717.

48. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599–607.

49. Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333–362.

50. Doppelt, Y., Schunn C. D., Silk, E. M., Mehalik, M. M., Reynolds, B., & Ward, E. (2009). Evaluating the impact of facilitated learning community approach to professional development on teacher practice and student achievement. *Research in Science and Technological Education, 27*(3), 339–354; Kleickmann, T., Trobst, S., Jonen, A., Vehmeyer, J., & Moller, K. (2016). The effects of expert scaffolding in elementary science professional development on teachers' beliefs and motivations, instructional practices, and student achievement. *Journal of Educational Psychology, 108*(1) 21–42; Marek, E., & Methven, S. B. (1991). Effects of the learning cycle upon student and classroom teacher performance. *Journal of Research in Science Teaching, 28*(1), 41–53.

51. Landry, S. H., Swank, P. R., Smith, K. E., Assel, M. A., & Gunnewig, S. B. (2006). Enhancing early literacy skills for preschool children: Bringing a professional development model to scale. *Journal of Learning Disabilities, 39*(4), 306–324; Saxe, G. B,, Gearhart, M., & Nasir, N. S. (2001). Enhancing students' understanding of mathematics: A study of three contrasting approaches to professional support. *Journal of Mathematics Teacher Education, 4*(1), 55–79.

52. National Commission on Teaching and America's Workforce. (2016). What matters now: A new compact for teaching and learning. Arlington, VA: National Commission on Teaching and America's Future. https://nctaf.org/wp-content/uploads/2016/09/NCTAF_What-Matters-Now_The-Evidence-Base_hyperlinked.pdf (accessed 5/2/17).

53. Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science, 333*(6045), 1034–1037.

54. Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science, 333*(6045), 1034–1037.

64. Lara-Alecio, R., Tong, F., Irby, B.J., Guerrero, C., Huerta, M., & Fan, Y. (2012). The effect of an instructional intervention on middle school English learners' science and English reading achievement. *Journal of Research in Science Teaching, 49*(8), 987–1011.

65. Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science, 333*(6045), 1034–1037.

66. Allen, J. P., Hafen, C. A., Gregory, A. C., Mikami, A. Y., & Pianta, R. (2015). Enhancing secondary school instruction and student achievement: Replication and extension of the My Teaching Partner-Secondary intervention. *Journal of Research on Educational Effectiveness, 8*(4), 475–489; Shaha, S.H., & Ellsworth, H. (2013). Predictors of success for professional development: Linking student achievement to school and educator successes through on-demand, online professional learning. *Journal of Instructional Psychology, 40*(1), 19–26.

67. Landry, S. H., Anthony, J. L., Swank, P. R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology, 101*(2), 448–465.

68. Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333–362.

69. Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333–362.

70. Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching, 49*(3), 333–362.

71. Kleickmann, T., Trobst, S., Jonen, A., Vehmeyer, J., & Moller, K. (2016). The effects of expert scaffolding in elementary science professional development on teachers' beliefs and motivations, instructional practices, and student achievement. *Journal of Educational Psychology, 108*(1) 21–42.

72. Doppelt, Y., Schunn C. D.rlE Schu0019000C001143Eu1ty40030etnc

87. Greenleaf, C. L., Hanson, T. L., Rosen, R., Boscardin, D. K., Herman, J., Schneider, S. A., Madden, S., & Jones, B. (2011). Integrating literacy and science in biology: Teaching and learning impacts of reading apprenticeship professional development. *American Educational Research Journal, 48*(3), 647–717.

88. Landry, S.H., Anthony, J.L., Swank, P.R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology, 101*(2), 448–465.

89. Landry, S.H., Anthony, J.L., Swank, P.R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology, 101*(2), 448–465.

90. Landry, S. H., Anthony, J. L., Swank, P. R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology, 101*(2), 448–465.

91. Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*; Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29; Landry, S. H., Anthony, J. L., Swank, P. R., & Monseque-Bailey, P. (2009). Effectiveness of comprehensive professional development for teachers of at-risk preschoolers. *Journal of Educational Psychology, 101*(2), 448–465; Powell, D. R., Diamond, K. E., Burchinal, M. R., & Koehler, M. J. (2010). Effects of an early literacy professional development intervention on Head Start teachers and children. *Journal of Educational Psychology, 102*(2), 299–312.

92. Allen, J. P., Hafen, C. A., Gregory, A. C., Mikami, A. Y., & Pianta, R. (2015). Enhancing secondary school instruction and student achievement: Replication and extension of the My Teaching Partner-Secondary intervention. *Journal of Research on Educational Effectiveness, 8*(4), 475–489; Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science, 333*(6045), 1034–1037; Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*; Powell, D. R., Diamond, K. E., Burchinal, M. R., & Koehler, M. J. (2010). Effects of an early literacy professional development intervention on Head Start teachers and children. *Journal of Educational Psychology, 102*(2), 299–312.

93. Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29; Lara-Alecio, R., Tong, F., Irby, B. J., Guerrero, C., Huerta, M., & Fan, Y. (2012). The effect of an instructional intervention on middle school English learners' science and English reading achievement. *Journal of Research in Science Teaching, 49*(8), 987–1011; Roth, K. J., Garnier, H. E., Chen, C., Lemmens, M., Schwille, K., & Wickler, N. I .Z. (2011). Videobased lesson analysis: Effective science PD for teacher and student learning. *Journal on Research in Science Teaching, 48*(2),117–148; Taylor, J. A., Roth, K., Wilson, C. D., Stuhlsatz, M. A., & Tipton, E. (2017). The effect of an analysis-of-practice, videocase-based, teacher professional development program on elementary students' science achievement. *Journal of Research on Educational Effectiveness, 10*(2), 241–271.

94. Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*; Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29.

95. Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession*. Washington, DC: National Staff Development Council; Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational researcher, 38*(3), 181–199.

96. Knapp, M. S. (2003). Professional development as policy pathway. *Review of Research in Education, 27*(1), 109–157.

97. None of the reviewed studies explicitly utilized a one-off workshop as their preferred model. However, four of the studies do not specify the duration or structure for professional development sessions. Based

118. Lieberman, A., & Wood, D. (2002). From network learning to classroom teaching. *Journal of Educational Change, 3*, 315–337; McDonald, J. P., Buchanan, J., & Sterling, R. (2004). The national writing project: Scaling up and scaling down. *Expanding the reach of education reforms: Perspectives from leaders in the scale-up of educational interventions*, 81–106.

119. Lieberman, A., & Wood, D. (2002). From network learning to classroom teaching. *Journal of Educational Change, 3*, 315–337; McDonald, J. P., Buchanan, J., & Sterling, R. (2004). The national writing project: Scaling up and scaling down. *Expanding the reach of education reforms: Perspectives from leaders in the scale-up of educational interventions*, 81–106.

120. Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*.

121. Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*.

122. Gallagher, H. A., Woodworth, K. R., & Arshan, N. L. (2017). Impact of the National Writing Project's College-Ready Writers Program in high-need rural districts. *Journal of Research on Educational Effectiveness, online*, 37.

123. Hill, H. C., Beisiegel, M., & Jacob, R. (2013). Professional development research: Consensus, crossroads, and challenges. *Educational Researcher, 42*(9), 476-487.

124. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599-607; Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29.

125. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599–607.

126. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 606.

127. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 606.

128. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 606.

129. Buczynski, S. & Hansen, C. B. (2010). Impact of professional development on teacher practice: Uncovering connections. *Teaching and Teacher Education, 26*(3), 599–607.

130. Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29.

131. Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 22-23.

132. Johnson, C. C., & Fargo, J. D. (2010). Urban school reform enabled by transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4–29.

133. Tooley, M., & Connally, K. (2016). *No panacea: Diagnosing what ails teacher professional development before reaching for remedies*, 12. Washington, DC: New America.

134. Tooley, M., & Connally, K. (2016). *No panacea: Diagnosing what ails teacher professional development before reaching for remedies*. Washington, DC: New America.

135. Hargreaves, A., & Fullan, M. (2012). *Professional capital: Transforming teaching in every school.* Teachers College Press.

136. Learning Forward provides a set of standards for professional learning that overlap to some degree with the elements of effective professional learning we have outlined here. See, https://learningforward.org/standards-for-professional-learning.

About the Authors

1530 Page Mill Road, Suite 200
Palo Alto, CA 94304
p: 650.332.9797

1301 Connecticut Avenue NW, Suite 500
Washington, DC 20036
p: 202.830.0079
@LPI_Learning | learningpolicyinstitute.org