A Model for Evaluating Science Teacher Professional Development Projects

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Abstract

Multi-site professional development (PD) evaluation attempts to document common outcomes across projects in order to make claims about the value of a PD program as a whole. This is a reasonable goal for funding agents, which need to demonstrate the effectiveness of programs in advancing teacher quality and student achievement. Yet, is it reasonable to expect that PD projects, which deliver a variety of science and pedagogical content to very different teachers (grade level, science content background, teaching experience) from diverse schools settings (urban, suburban, rural), would have similar outcomes? Since 2002, our team has served as the external evaluators for our state's *Improving Teacher Quality Grants* program, funded by US federal flow through dollars. To date we have evaluated over 50 PD projects for science and mathematics teachers funded under this program. We found that the design and implementation characteristics of professional development matter. Outcomes do not stand alone, nor do they tell the entire story. In this paper, we discuss a model for science teacher PD evaluation that takes into account both PD characteristics and outcomes variables. We also describe how we apply the construct of orientations (based on the pedagogical content knowledge model) to understanding PD design and outcomes.

A model for evaluating science teacher professional development projects

One purpose of professional development (PD) evaluation is to judge the effectivenss of a PD project in light of its objectives. Multi-site PD evaluation attempts to document common outcomes across projects in order to make claims about the value of a PD program as a whole. It is reaonable for funding agents to require evaluation reports that demonstrate the effectiveness of PD projects and programs in advancing teacher quality and student achievement, and many professional developers include an evaluation component in their PD program plans. Researchers have evaluated the effectiveness of mathematics and science teacher PD programs by examining individual cases of PD (e.g., Akerson & Hanuscin, 2007; Annetta & Shymansky, 2006; Jauhiainen, Lavonen, Koponen, & Suonio, 2002; Khourey-Bowers & Simonis, 2004; Shepardson Harbor, Cooper, & McDonald, 2002). Others, such as Supovitz and Turner (2000), used a multiple site approach to PD evaluation in science education. In the typcial PD evaluation study, program outcomes for teachers and students are the focus. Although researchers acknowledge the role of content, context, and process factors in PD outcomes (Fishman, Marx, Best, & Revital, 2003), seldom do published studies describe PD design and implementation in a manner that provides an understanding of the individual PD treatment or that allows comparison across multiple PD projects of similar design.

Because PD projects deliver a variety of science and pedagogical content to different types of teachers (in terms of grade level, courses taught, teaching experience) from diverse schools settings (urban, suburban, rural), is it reasonable to examine outcomes without respect to such context characteristics? Since 2002, I have led a group of researchers that serves as the external evaluation team for our state's *Improving Teacher Quality Grants (ITQG)* program, funded by US federal flow through dollars. To date we have evaluated over 50 PD projects for science and mathematics teachers funded under this program. In our evaluation work, we found that the design and implementation characteristics of professional development matters. Outcomes do not stand alone, nor do they tell the entire story. In this paper, I outline a model for science teacher PD evaluation that takes into account both PD characteristics and outcomes, and describe a new construct that we have identified as an important PD feature.

Models of PD Evaluation

Professional development evaluation design rests upon theoretical models of the relationships among PD characteristics and outcomes. For example, Medina, Pollard, Schneider, and Leonhardt (2000) suggested a traceable link from PD to teacher learning, teacher practice, and student learning. Guskey and Sparks (1996) proposed a model based on the premise that the quality of PD is influenced by content, context, and process factors. *Content* factors include the knowledge and skills to be developed as well as the degree of change required to enact the new knowledge and skills. *Context* factors include the "who, when, where, and why of professional development" (Guskey, 2000, p. 74). *Process* refers to PD delivery format and instructional strategies. Guskey and Sparks claimed that these factors affect the quality of PD, which in turn influences outcomes (knowledge and practices) for the teachers, administrators, and others involved. These outcomes can have an impact on student learning. "Although the relationship between professional development and improvement in student learning is complex, it is not random or chaotic" (Guskey, pp. 76-77). Furthermore, according to Loucks-Horsley, Love, Stiles, Mundry, and Hewson 2003), outcomes of PD, such as teacher and student learning, provide a feedback loop to professional developers as they design and deliver subsequent PD.

Theoretical models of the relationship of PD characteristics to teacher and student learning outcomes have implications for PD evaluation. Guskey (2000) proposed a model for evaluating PD that is hierarchical in nature. According to this model, PD evaluation should move from the simple (reactions of participants), to the more complex (student learning outcomes), with data from each level building on the previous. His model consists of evaluation at five levels: (1) participant reactions; (2) participant learning; (3) organization support and change (4) participant use of new knowledge and skills, and (5) student learning outcomes. Each level addresses a certain set of questions and informs the types of evaluation data to be collected. At Level 1, evaluators ask if the participants liked the PD through questionnaires and interviews. For Level 2, evaluators ask if participants learned the intended knowledge and skills. They gather evidence through tests, presentations, and artifacts. At Level 3, evaluation is concerned with the impact on the organization (i.e., the school, school district, institution of higher education). Questionnaires, interviews, and artifacts can provide such information. Level 4 focuses on how participants apply their new knowledge and skills in their classrooms and schools. Evaluators use questionnaires, interviews, written reflections, and observations as evidence. Level 5 is concerned with the impact of PD on student achievement, performance, attitudes, and self-efficacy. Evidence of PD impact on students comes from school records, questionnaires, interviews, and artifacts such as tests. Guskey claimed that good PD evaluation addresses all five levels.

Our Model of PD Evaluation

To evaluate PD programs in a way that takes into account both project characteristics and outcomes, we synthesized models from Guskey and Sparks (1996), Guskey (2000), and Loucks-Horsley et al. (2003) (see Figure 1). The project characteristics form an outer circle around outcomes, indicating the importance of content, context, and process in understanding PD outcomes. The outcomes are contained within a permeable membrane, indicating the feedback that takes place back and forth between project characteristics and outcomes. We also modified Guskey's hierarchical arrangement of outcomes to demonstrate a slightly different set of connections among the levels. This new model provides guidance for PD evaluators (Abell et al., 2007). The model implies:

1. That PD outcomes, including teacher reactions, knowledge, and change in practice, as well as organizational change and support, can affect student learning.
2. That outcomes must be interpreted in light of process, content, and context characteristics of each PD project.

Our PD evaluation processes are directly linked to this model, and demand a mixed method evaluation design (Chatterji, 2004). More specifically:

1. We characterize the process, content, and context variables associated with each project that we evaluate. We do this through site visits to each project, interviews with project staff and participants, and analysis of artifacts such as the project grant propoosal. This requires mainly qualitative methods.
2. We measure teacher reactions, knowledge gains, and perceived change in practices, as well as institutional change, across all PD projects. This requires quantitative and qualitative methods.
3. We examine student achievement data, attempting to attribute student learning outcomes to PD activities. This requires quantitative methods.

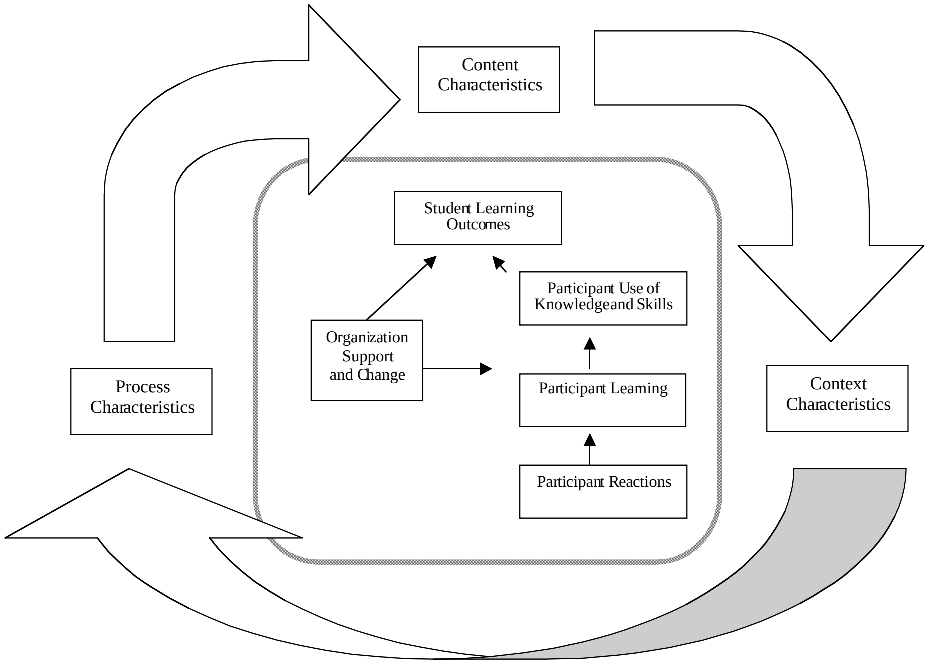

Figure 1: An Adaptation of Guskey's (2000) Model for Evaluating Professional Development Programs (from Abell et al., 2007)

Orientations to PD: A Critical PD Characteristic

In the ITQG program that we evaluate, many of the funded PD projects look quite similar on the surface. Because the PD developers respond to the same Request for Proposals (RFP), they formulate similar goals (related to teacher and student learning) and use similar delivery approaches (typically a summer institute and school year follow-up sessions). That is, some parts of the outer circle of PD characteristics in our evaluation model (Figure 1) are similar. Yet we knew from our observations of these projects, than they were in fact remarkably different. Thus we sought a means for understanding differences among projects that, on the surface, looked very similar.

According to Loucks-Horsley et al. (2003), PD design and implementation is grounded in inputs from various external factors, including professional developers' knowledge and beliefs. Examining professional developers' knowledge and beliefs has been neglected in the evaluation of science PD projects. To understand professional developers' knowledge and beliefs, we included a new construct in our evaluation. This construct is grounded in Shulman's (1986) notion of pedagogical content knowledge (PCK) for teaching specific subjects. We believe that PCK can be extended to the knowledge and beliefs that science teacher educators use in professional development settings (see Abell, Park Rogers, Hanuscin, Gagnon, & Lee, 2009). In other words, professional developers who design and deliver PD to science teachers have knowledge and beliefs about PD that influence how they design and deliver PD. Specifically, a professional developer's PCK includes his/her knowledge about curriculum, instruction, and assessment for designing and delivering PD, knowledge about how teachers learn, and orientations to PD design and enactment. In our current work, we examine how the construct of PD Project Orientation can help evaluators characterize PD.

The construct of PD Project Orientation grows out of the literature on orientations related to science teaching. Anderson and Smith (1987) introduced and defined the construct of orientation toward science teaching as “general patterns of thought and behavior relating to science teaching and learning (p. 99). They proposed four orientations for teaching science: activity-driven teaching; didactic teaching; discovery teaching; and conceptual-change teaching. Magnusson, Krajcik, and Borko (1999), building upon Anderson and Smith’s work, identified an additional five orientations toward teaching science: process; academic rigor; project-based science; inquiry; and guided inquiry. Musikul and Abell (2009) extended the orientation construct to consider individual professional developers’ orientations to teaching teachers of science. They empirically documented that professional developers have orientations towards professional development and that their orientations influence the way that they design and implement professional development opportunities for teachers of science, as well as the way they interpret the outcomes. In our evaluation work, we found that most PD projects were co-constructed by a team of PD developers. Thus we identified PD Project Orientation as applied to an entire PD project rather than to a single individual’s views.

Five Orientations to PD

From our evaluation work, we hypothesized a number of PD Project Orientations. We then performed an in-depth of analysis of nine science PD projects using the full set of data sources we had collected during our evaluation. This analysis led us to define five orientations to PD design and implementation: activity-driven, science content-driven; pedagogy-driven; curriculum-materials driven; and needs-driven (Park Rogers et al., in press). We present each of these with a short description of the orientation as displayed in PD projects.

Activity-driven. The primary goal of projects identified as having an activity-driven orientation was to enhance teacher knowledge of content and inquiry by engaging them in a series of hands-on activities that they could later reproduce in their classrooms. An activity-driven PD project was designed to introduce teachers to several new activities during the summer workshop and/or school year follow-up sessions that they could easily replicate in their classroom. In a project with an activity-driven orientation, the PD team selected and implemented a set of activities related by content, but rarely structured the activities by using a purposeful sequence for conceptual model building, nor did the PD team and participants discuss the pedagogical implications of the activities. The role of the instructional team of a PD project with an activity-driven orientation was demonstrating or modeling; they implemented each activity with the teacher participants as though the PD setting was a K-12 classroom. Teachers received lesson plans or were given time to develop their own lessons or units that showed how they would replicate the kinds of activities they experienced in the PD in their own classrooms. In addition, teachers were often provided with the science materials (e.g., kits or equipment) necessary to carry out the activities in their schools.

Content–driven. The goals of PD projects identified as having a science content-driven orientation were to increase teachers’ science content knowledge, including their understanding of science concepts and scientific inquiry, as well as their confidence in science. The role of the PD developers in a project with a science content-driven orientation was often didactic in nature; PD developers were knowledge givers, while teachers were knowledge receivers and spent significant time taking notes. The content was often delivered in the form of lecture or whole class discussion, with an occasional hands-on activity, lab, or simulation software to help illustrate or provide an opportunity for application of the content learned. Projects representing a content-driven approach were often led by scientists, as opposed to science educators.

Pedagogy-driven. The focus of projects with a pedagogy-driven orientation was to expose teachers to an inquiry-based instructional model (e.g., the learning cycle; the 5E model) and complementary instructional strategies (e.g., questioning, journaling, cooperative learning, student-led investigations, or white-boarding) that they could incorporate into their science teaching. A PD project reflective of a pedagogy-driven orientation incorporated extensive modeling of the strategies by the professional developers and provided opportunities for the teacher participants to experience the strategies in a manner similar to their students. In addition, the PD team asked the teachers to reflect on the modeled practices from a learner's perspective, as well as how they could apply the strategies to their own teaching practice. These projects were typically led by science educators.

Curriculum materials-driven. PD projects identified as having a curriculum materials-driven orientation tended to be more highly structured than other PD projects. In these projects, professional developers chose a locally or nationally developed and field-tested curriculum and then worked through each lesson step-by-step with the teachers so they would know how to implement the intended curriculum in their own classrooms. The purpose of projects exhibiting this orientation was to have the teachers experience the science problems and investigations of the curriculum in the same manner that their students would, and to consider ways to help the students work through certain points of confusion or frustration in the lessons. The professional developers believed that having the teachers experience the curriculum from a student's perspective would give the teachers better insight as to how to guide student learning. Further, these projects differed from projects with a pedagogical orientation in that the instructional methods were often implied throughout the curriculum, but there was no explicit instruction related to them. The teachers in curriculum materials-driven projects left the PD with a copy of the teacher's manual and either a demonstration or full class set of all materials necessary to use the curriculum in their own classroom.

Needs-driven. The single PD project we observed with a needs-driven orientation was designed around the needs of the teacher participants and relied on the teacher participants to come to the project with particular learning goals in mind. This approach required the PD team to deliver an experience that was somewhat individualized to meet the teachers' needs. The PD team members completed a needs-assessment with each teacher prior to the PD summer workshop and then focused the delivery of the PD to support these various needs -- sometimes grouping teachers together with similar needs and sometimes giving teachers time to work independently. The PD project team viewed their role as one of support, stepping in when the teachers required their assistance.

Conclusion

The PD Project Orientation construct provides a framework to characterize PD design and implementation and, potentially, to understand PD outcomes (see Figure 2) by distinguishing the nuances within a single project and across multiple projects. Ultimately, this could lead to understanding that a particular orientation or combination of orientations that may result in greater improvements in science teaching and learning in the classroom. Although we do not claim that the five PD project orientations described represent an exhaustive list, we believe they provide a powerful framework for understanding PD. Using the PD Project Orientation construct, researchers can characterize PD and use that characterization to understand PD outcomes. Whereas previous researchers (e.g. Banilower, Heck, & Weiss, 2007; Boyle, While & Boyle, 2004) found PD outcomes to be linked to a number of *individual* variables (e.g., number of hours of PD; connectedness of PD activities; opportunities for teacher collaboration; content emphasis), the PD Project Orientation construct represents a more holistic way to examine PD projects that encompasses the knowledge and beliefs of PD developers as well as the context, content, and process of the PD projects. We believe this construct allows researchers to describe PD in ways that accounts for the complexity of PD design and implementation.

INSERT FIGURE 2 HERE

Much is written about factors that professional developers need to consider when designing an effective PD experience (Abell et al., 2007; Garet et al., 1999; 2001; Guskey, 2000; Loucks-Horsley et al., 2003; National Staff Development Council, 2001). However, little has been written about the connections among PD design, delivery, and outcomes. We believe that explicit attention should be paid to PD Project Orientation at the design phase. We encourage PD developers to be reflective about their design decisions by attempting to make their individual orientations explicit to themselves and their team members as these, together with other external factors such as context, will impact the resulting PD implementation and outcomes.

The application of the construct of PD Project Orientations to characterizing the design and delivery of PD projects provides a new tool for understanding the effectiveness of science teacher PD. With national and international calls for improving the quantity and quality of science teachers, it is imperative that we plan and deliver high quality PD that will help teachers learn both new science content and reform-based pedagogies. We believe that applying an orientations construct to the study of PD effectiveness can allow researchers to explore the forces that influence design and implementation decisions of PD project personnel, how multiple orientations shape these decisions, and what outcomes result. Studies such as these have the potential to improve the quality of PD, leading to more highly qualified science teachers for our schools.

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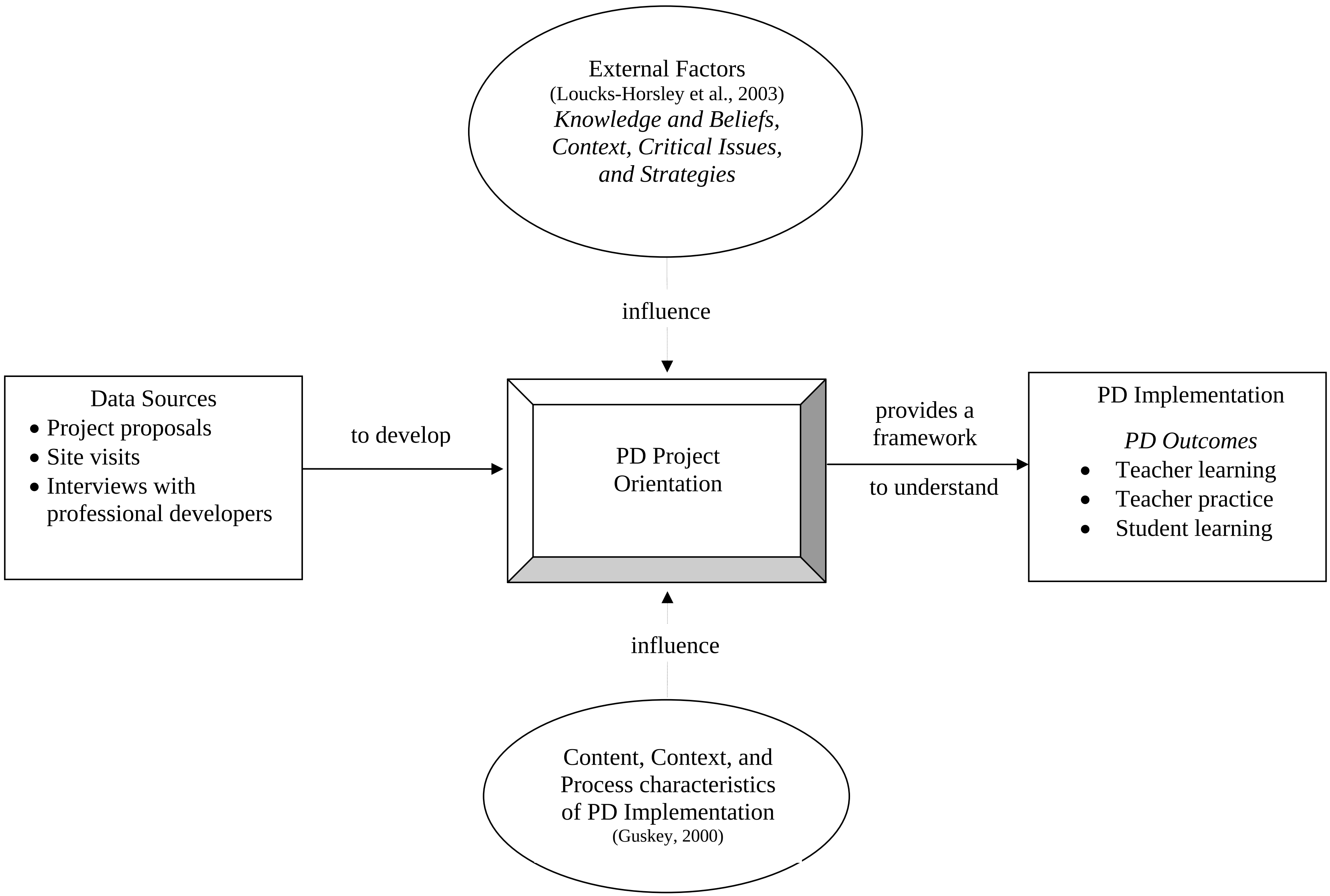

Figure 2. PD project orientation as a framework for holistic description of PD characteristics (from Park Rogers et al., in press)