# Orientations to Professional Development Design and Implementation: Understanding Their Relationship to PD Outcomes Across Multiple Projects

Rose M. Marra, Fran Arbaugh, John Lannin, Sandra Abell, Mark Ehlert,
Rena Smith, Dominike Merle
University of Missouri
Meredith Park Rogers
Indiana University

*Abstract*

Given the large investment in teacher professional development, there is a need to understand the factors that impact PD success. In a previous study, the authors established a framework for categorizing PD projects using the notion of orientations. This framework is based on how PD designers approach design and implementation. In this study we applied this orientation framework to 14 science and mathematics PD projects and examined the relationship between projects of differing orientations and PD outcomes (e.g. perceived improvement in teaching practices). Results confirm both the value of the framework as well as show that PD projects with different orientations do show different perceived participant outcomes. The study provides evidence of the value of this research framework for understanding how PD implementation characteristics are related to PD outcomes.

## *Introduction*

Professional development (PD) for science and mathematics teachers has, over the past two decades, increased dramatically in offerings. Interested teachers often do not need to look far for professional development opportunities, particularly with the advent of on-line PD (e.g., National Council of Teachers of Mathematics' *E-Workshops* and the National Science Teacher Association's *Web Seminars*). In addition, major funding has been dedicated to the professional development of mathematics and science teachers through organizations like the National Science Foundation. Further, with support of federal flow-through monies, many states fund PD projects through *Mathematics and Science Partnership* and *Improving Teacher Quality Grants* programs. One result of all of these opportunities for PD is that there are more and more PD providers across the country, designing and delivering PD projects for science and mathematics teachers.

Designing and delivering effective PD is a complex task that must take into account professional developers' knowledge, beliefs, and past practices, as well as the setting, participants, and PD implementation. Loucks-Horsely, Love, Stiles, Mundry, and Hewson (2003) addressed the complex nature of PD design and delivery in describing their process of creating the Professional Development Design Framework, which "emerg[ed] originally from collaborative reflection with outstanding professional developers about their programs for both mathematics and science teachers" (p. 2):

> As professional development "designers," they consciously drew on research and "practitioner wisdom" and were guided by their own passionate beliefs about the nature of mathematics and science and student and adult learning. They had a repertoire of

> strategies from which to choose. They grappled with challenging, critical issues related to the “big picture” of mathematics and science education reform. They analyzed student learning data and student work and studied their own unique contexts to deliberately set goals to improve student and teacher learning and classroom practice. They thought carefully about what approach would be best in a particular time and place to advance their goals and plans. Once implemented, their designs never stopped evolving. (p. 2-3)

This description suggests that the outcomes of a particular PD experience may well depend upon the PD designers’ knowledge, beliefs, and experiences.

Several models (e.g., Guskey, 2000; Loucks-Horsley et al., 2003) and standards documents exist (e.g., National Staff Development Council, 2001) outlining characteristics of effective PD – characteristics that are grounded in the PD research literature. Most of those lists contain research-based characteristics related to: (a) the mechanism of the PD (e.g., effective PD is “continuous and on-going, involving follow-up and support for further learning” [Hawley & Valli, 1999, p. 138]); (b) the content of the PD (e.g., effective PD “focuses on specific issues of curriculum and pedagogy derived from research” [Elmore, 2002, p. 7]); and/or (c) the origination of the PD content (e.g., effective PD “addresses issues of concern and interest, largely (but not exclusively) identified by the teachers themselves” [Clarke, 1994, p. 38]).

These characteristics of effective PD, however, are not grounded in research on the professional developers’ knowledge, beliefs, and experiences – influences that can have a major impact on PD outcomes (as argued by Loucks-Horsley, et al. [2003] and cited above). As a community, we know little about professional developers themselves or how their knowledge, beliefs, and backgrounds ultimately impact PD design and thus the outcomes of PD.

Knowledge, beliefs, and experiences define one’s “orientation” toward teaching and learning (Anderson & Smith, 1987) a given subject matter. Much like science teachers holding various orientations to teaching science, we believe that teacher educators have orientations to teaching teachers in professional development settings, shaped by their knowledge, beliefs, and experiences. In a previous study (Park Rogers, Abell, Marra, Arbaugh, Hutchins, and Cole, 2008), we examined the beliefs of professional developers and described how they shaped the different orientations to PD that were displayed by individual PD projects. In the present study, we applied the *PD Orientations Framework* established in our previous research to 14 science and mathematics projects that were funded through a *Improving Teacher Quality Grants* (ITQG) program in one state. We rated projects by their orientation to PD together with a variable which describes the strength or consistency of the project's orientation, and examined the differences in participant responses to the PD. Our research questions were:

1. What are the orientations of the 14 projects and how do teacher participants’ perceptions of their projects align with researcher ratings?

2. Are there differences in project outcomes based on orientation and how consistently the orientations are implemented in teacher self-reported ratings of:
    - Impact on teaching practices?
    - Contributions of PD aspects to teaching practice?
    - Teacher confidence in subject matter and teaching knowledge?

## *Theoretical Framework*

The notion of orientations to PD (Park Rogers, et al., 2008) has its basis in Shulman's model (1986; 1987) of specialized knowledge for teaching different disciplines, commonly referred to as pedagogical content knowledge (PCK). Shulman's initial work on PCK has been extended by a number of researchers in different fields (e.g., Grossman (1990) in English Education; Hill, Ball, & Shilling (2008) in Mathematics Education; Magnusson, Krajcik, & Borko (1999) in Science Education). These evolving frameworks support the educational community's understanding and research of the knowledge teachers develop and use in teaching specific content to K-12 students – knowledge that is unique to the teaching of that specific content.

In addition to identifying types of knowledge that teachers develop and use, researchers in the area of teacher knowledge introduced the concept of "orientations" towards teaching and learning as a mitigating factor in teachers' use of their knowledge in practice (e.g., Anderson & Smith, 1987). For science teaching, Magnusson, Krajcik, and Borko (1999), defined orientations as "teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular grade level" (p. 97). Further, they stated, "An orientation represents a general way of viewing or conceptualizing science teaching" (p. 97). Magnusson and her colleagues identified nine different orientations to teaching science in the literature: process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry, and guided inquiry.

Our research paradigm extends the concept of orientations to PD developers. We claim that PD developers have specialized knowledge for teaching teachers (Park Rogers, et al., 2008), which includes the component of "orientations to PD." A PD orientation includes beliefs about the purpose and goals for PD and these orientations guide PD design and implementation (Park Rogers, et al., 2008). A few studies have explored orientations towards the teaching of science in teacher preparation programs (Abell & Bryan, 1997), college science courses (Volkmann, Abell, and Zgagacz, 2005), and with the implementation of science curricula (Barrett and Pedretti, 2006). In previous work (Park Rogers, et al., 2008), we empirically established five orientations to PD: activity-driven, content-driven, pedagogy-driven, curriculum materials-drive, and needs-driven (see Table 1).

Table 1. Orientations to PD (Park Rogers, et al., 2008)

| |
|---|
| *Activity-driven*. Engage teachers in hands-on activities (e.g. modeling erosion patterns) intended for use with students. The conceptual or pedagogical value of the activity is not always made explicit—the value is assumed to be in the activity itself. |
| *Science / Mathematics content-driven.* Help teachers learn new content (e.g. Newton's laws) and laboratory techniques to enhance teachers' understanding of selected concepts |
| *Pedagogy-driven.* Encourage and model particular instructional strategies (e.g., white-boarding, questioning strategies) that would help teachers help students learn. |
| *Curriculum materials-driven*. Guide participants through lessons and units from nationally or locally developed and field-tested curriculum materials to help teachers learn to use those materials in their classes. |
| *Needs-driven*. Enlist teachers to establish needs, design instruction, and implement instruction. Teacher networking is a major feature of this approach. |

Yet to be studied is how orientations are related to PD outcomes. The purpose of this study is to initiate discussion about this relationship.

*Factors that Influence Professional Development Outcomes*

Given this framework, we examine literature on science and mathematics professional development (PD) that seeks to understand what characteristics of PD are related to important teacher PD outcomes – such as changes in teacher confidence in their subject matter and impact on teacher behaviors. In particular we examine studies that examine these outcomes across multiple PD projects that may be implemented in different ways but seek the same outcomes. We limit our review to studies that examined PD's impact on teacher outcomes (rather than student outcomes); these are more prevalent in the literature (Kennedy, 1999) and are in alignment with our current study.

Much has been written about the characteristics of effective professional development. For example, Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003) provide a framework for designing PD, information about knowledge and beliefs that support effective PD, contextual factors that influence PD, critical issues to consider in designing PD, and strategies to use to organize PD. Further, the need for sustained support for teachers once they return to their classrooms is also an element commonly discussed in the PD literature (Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Guskey, 2000; Loucks Horsley et al., 2003; Thompson & Zeuli, 1999). Sowder's (2007) review of PD literature in mathematics education (Clarke, 1994; Elmore, 2002; Hawley & Valli, 1999) emphasizes the importance of PD that is grounded in "sound theories of learning, particularly adult learning" (p. 170). Finally, Park Rogers, Abell, Lannin, Wang, Musikul, Barker, and Dingman (2007) examined teachers' views of effective PD in comparison to professional developer's views to shed light on how various participants of science and mathematics PD interpret the effectiveness of a PD experience in different ways.

The research literature in science and mathematics education contains a multitude of empirical studies that examine how different characteristics of PD are related to PD outcomes such as teachers' knowledge and beliefs (e.g., confidence in their content knowledge), and teachers' practices (e.g., use of inquiry in the classroom). Borko (2004) provides a scheme for understanding PD research as she describes three phases of PD research. Phase 1 research focuses on an individual PD program at a single institution; Phase 2 research examines a single PD program that is implemented by multiple institutions and in Phase 3, researchers compare multiple programs implemented at multiple sites. Borko calls for more phase 3 research; our study meets this need and further introduces a new framework for understanding holistic attributes of PD and how they may contribute to PD outcomes. Using this scheme, our study is at Phase 3 and examines PD projects that responded to a single RFP but were implemented in multiple locations and in multiple designs; thus we begin our literature review with other Phase 3 studies of mathematics and science PD.

A major study of large-scale PD efforts that has been conducted in the past decade was connected to another NSF funding program – the Local Systemic Change through Teacher Enhancement Initiative (LSC). Banilower, Heck, & Weiss' (2007) study of over 18,000 teachers from the 42 LSC projects examined, among other things, the relationship between participation in PD and teacher attitudes, perceptions of preparedness and teacher behaviors. Results showed that teachers who spent more hours in LSC PD scored significantly higher on measures of attitudes towards standards-based teaching, their own perceptions of pedagogical preparedness and content preparedness. They also found that a positive relationship between hours spent in PD and frequency of use of the LSC instructional materials and the time spent per week doing classroom science instruction.

A large-scale survey study conducted in England had a specific purpose; it sought to examine the premise that PD that has a large number of contact hours and is delivered over a sustained period of time will have a bigger impact on teaching practice that PD that has a more limited duration (Boyle, While & Boyle, 2004). These researchers sampled broadly across England and essentially audited PD involvement in English, mathematics and science. Longer term PD resulted in changes in teaching practice with the most changes occurring in planning (over half of the respondents indicated this type of change); changes to teaching style (43%) and assessment practices (40%) were also commonly reported.

In another multi-site large scale study, Ingvarson, Meiers, and Beavis (2005) investigated the impact of PD background variables (e.g., school size), structural features (e.g., contact hours), opportunity to learn (e.g., feedback on practice), and professional community (e.g., teacher collaboration) on four outcome variables: teacher knowledge, teaching practice, student learning, and teacher efficacy. They collected data from 3250 Australian elementary and secondary teacher participants who attended over 80 different PD programs in a variety of subject areas, including mathematics and science and found significant impact of content focus, presence of active learning, and PD follow-up on teacher knowledge and sense of professional community.

Several studies from a group of researchers (Desimone, Porter, Garet, Yoon, and Birman ,2002; Garet, Porter, Desimone, Birman, & Yoon, 2001; Garet, Birman, Porter, Desimone, & Herman, 1999) assessed the effects of a three-year, five state mathematics and science PD initiative associated with the federally-funded Eisenhower program. Unlike the prior research that examined individual features of PD (e.g. duration), their research and PD project was on six key “structural features” (Desimone et al., 2002, p. 83) of PD that were hypothesized to improve teaching practices: Form or organization of the activity, activity duration, degree activity emphasizes “collective participation” (p. 83) of teacher groups, degree of active learning of activity, and the degree that activity promotes coherence in teachers PD, degree of content focus of activity. They found that these six features were related to increases in the participants’ reported increases in knowledge and skills and changes in teaching practices Garet et al., 2001; Garet et al., 1999). The researchers also conducted a longitudinal study to examine more closely the impact of different characteristics of PD on teacher practices (Desimone et al. (2002). They found that PD intended to increase a designated instructional practice must focus very specifically on that practice and also that there is a positive “spillover” (p. 99) effect for teacher practices from the PD area of that specific practice to the related practices.

Other studies of individual PD initiatives – Borko’s Phase I classification -- have also examined impact of PD on teacher outcomes. For instance, in a primarily qualitative study of a three –year project focused on secondary science teachers, researchers found that teachers more successfully implemented inquiry lessons when the PD included deep content knowledge, process knowledge and contained opportunities for practice (Jeanpierre, Oberhauser, and Freeman, 2005). In a two site study of a single PD project that engaged teachers in designing and conducting science research projects, researchers used inductive analysis to examine the impact of PD on teacher's understanding of science content knowledge. Results showed that teachers gained specific content knowledge as well as the ability to conduct like experiments with their students (Shepardson, Harbor, Cooper and McDonald, 2002).

As this literature shows, numerous studies have examined the impact of PD on teacher outcomes for both multiple and individual PD projects. With the exception of Desimone et al. (2002), these studies show how individual PD implementation characteristics such as project duration and years of teaching experience may predict or influence PD outcomes such as changes in teacher practices. Although our study is also concerned with teacher PD outcomes, our approach for relating PD to outcomes is different. Rather than examining outcomes as related to specific PD characteristics, we offer a framework for viewing PD projects more holistically – specifically via previously defined orientations to PD.

As Desimone et al. (2002) wrote, "Identifying and describing a professional development activity is complex" (p. 84). The approach used in this study differs in that it takes into account this PD complexity via orientation definitions that are multi-dimensional – that is they include not only distinct characteristics of PD implementation, but also the belief systems of PD leaders. We apply these orientations to multiple PD projects that responded to the same RFP and relate the applied orientations to teacher participant PD outcomes. Thus this study also meets Borko's (2004) stated need for more Phase 3 PD research where multiple programs implemented at multiple sites are compared.

## *Methods*

### *Context*

The 14 PD projects were funded by one cycle of funding of the *Improving Teacher Quality Grants* program in a Midwestern state. Thirteen projects held a summer institute. The other project did not hold a formal summer institute, but offered opportunities for teachers to choose 2-day PD workshops based on their needs. These workshops addressed various content and/or pedagogy and were held throughout the summer and fall. All projects held some type of school year follow up and addressed science, mathematics or both content areas for grades 4 - 8. The projects served 383 participants including 369 teachers, 10 pre-service teachers, 2 paraprofessionals, and 2 administrators (Abell, S., Ehlert, M., Lannin, J., Marra, R., & Arbaugh, F., 2007a). Funded PD projects were 17 months in duration and were required to include a partnership between a higher education institution and a high needs school district. Specifically, PD addressed teaching and learning in science, mathematics or both content areas and was designed to meet school needs and include job-embedded components.

### *Data Sources*

The authors are part of an external evaluation team for this state's ITQG program. Data sources and instruments originated from the evaluation work. However, the research questions, analysis, and results for this study are separate from our program evaluation work in that their intent is to generate new knowledge for the field, not judge the extent to which the ITQG program met its goals (Guskey, 2000). We used several qualitative data sources to establish each project's orientation. Primary data sources included audio files of interviews with project leaders conducted during two site visits to each project, field notes and observation protocols completed by the authors from these visits, each project's proposal to respond to the ITQG RFP and individual project profiles generated during our external evaluation.

We generated project profiles during the external evaluation which contained a description of how the project was designed and implemented (Abell, Lannin, Marra, Ehlert, Cole, Lee, Park Rogers, & Wang, 2007). Profiles were developed by two to three evaluation team members who served as liaisons to a PD project or were directly involved in that project's data. Profiles were based on the evaluation team members' first-hand site observations, the project proposal, how the project was perceived by project leaders and teachers and our analysis and synthesis of several data sources for the project including surveys and interviews of both leaders and teachers. For the purposes of classifying each project's orientation, we focused on the project background, design, and implementation sections from the project profile. (See Abell et al. [2007] for further details on the structure of the project profiles.)

We used the project profiles as a summarized view of each project; however we also used data sources generated from the authors' first-hand project experiences. Audio files from interviews with project leaders were one such source. Evaluation team members conducted semi-structured interviews with the project team leaders and other key leadership team members at the end of the summer institute (during the first project site visit). We re-interviewed the project leader and often other key team members during the second site visit. For this study we focused our analysis on the portion of the interviews that addressed the project goals, the state and national standards that informed the project design, the leaders' background in 6-12 science education and PD, and project implementation.

Other data sources included the researchers' site visit notes and an in depth observation protocol report all of which were completed during site visits. The observation protocol was based upon one originally developed to document the quality of K-12 science or mathematics classroom lessons (Horizon Research, Inc., 2000). We adapted the protocol to work for PD lessons thus allowing observers to collect data on the intended purposes of observed sessions, the instructional methods and activities used, and allowed observers to judge on the extent to which the workshop represented best practices in PD. Lastly, researchers examined artifacts gathered from the nine projects that reflected their PD project teams' vision for the PD, as well as other evaluation documents (for example, formative feedback reports developed for each project after observing a portion of the summer institute, the projects' proposals for funding, and observation notes created by at least two evaluation team members).

We derived data for the PD outcomes variables used in this study from the *Professional Development Evaluation Survey*. This instrument, designed by the evaluation team for the ITQG Program, was based on commonly cited components of effective PD from the RFP and in the research literature (i.e., planning lessons, developing materials, conducting activities, assessing students, and analyzing students' performance data). We administered the survey online at the end of the summer institute (*survey 1)* and again near the end of each PD project (*survey 2)*, usually at the middle or end of the following academic year. Both surveys included forced-choice and open-ended items. *Survey 1* had 55 forced-choice items plus 3 open-ended questions. *Survey 2* had 73 forced-choice items, 4 semi-structured questions, and 5 open-ended questions.

*Analyzing Outcomes Variables*

We analyzed selected portions of both surveys one and two that were pertinent to our research questions. For research question one (*What are the orientations of the 14 projects and how do teacher participant perceptions of their projects align with researcher ratings?*) we factor analyzed participant responses to 12 items on *survey 1* (end of summer institute) about the relative emphasis of PD components and examined the participant means on those factors relative to our researcher ratings of project orientations. For research question two (outcomes as related to orientations), we used items from survey one that addressed teacher participant's perceptions of how their teaching practices would improve due to PD, items from *survey 2* (end of project) that addressed teachers' perceptions of contributions of PD to aspects of teaching practice, and also survey two items that asked teachers to rate their level of confidence in science or mathematics content knowledge and teaching knowledge as a result of PD. Details on the statistical analysis procedures are presented with our results.

*Classifying PD Project Orientations*

To classify each project's PD orientation we reviewed the data sources described above. Two raters were assigned to examine each of the projects. One of the assigned raters on each team had *direct* experience with the project, either having conducted a site visit to the project or having worked as a project liaison. Raters were provided with definitions of the orientations (see Table 1) and instructed to use the project profile as well as their own personal experiences with the project (e.g., what a rater observed occurring during the summer workshop) to categorize each project with a "dominant" orientation. A dominant orientation was the orientation that guided both the design and delivery of the PD project throughout its entire implementation; a peripheral orientation played a significant role at some point in the PD project but not through its entire implementation. The lead author reviewed these ratings and the evidence provided for each. In a small number of cases where there appeared to be a misunderstanding of the orientation definition, the lead author worked with raters to clarify the orientation definitions and asked raters to revisit their ratings.

*Continuous vs. intermittent orientations.* During the orientations rating process, we observed that projects displayed their dominant orientation throughout the project in different ways. In some projects, the orientation was continuous—it guided all parts of the PD throughout the summer institute and during the school year follow-ups. In other projects, the orientation was intermittent; that is, it guided large parts of the PD project, but there were times when the orientation disappeared into the background while another orientation to PD came to the foreground.

An example of a continuously held orientation comes from the Sandon project. That project was guided by a pedagogy-driven approach. The major goal of the project was for teachers to learn to teach physics through a learning cycle approach. All project activities were conducted in a learning cycle format. When teachers learned new content, it was in the course of the learning cycle. As they learned activities from the new curriculum, they continually referred to the learning cycle approach. Thus, although there were several goals in the project, the goals were subsumed under the major goal of teaching using the learning cycle.

An example of an intermittently held PD project orientation was the Dalton project. The project's activity-driven orientation guided the design of most PD sessions. The project team put together a binder of science classroom activities for the teachers. During the PD, the teachers worked through each activity at a station, taking notes as if they were students. However, once in a while during the project, the PIs recognized that the teachers did not have the necessary science content knowledge to carry out the activity. Then the orientation would change to a content-driven orientation, where PIs would go to the front of the room and lecture teachers about the content. There was a disconnect between teachers learning activities and learning the content. The activities were not used to teach the content; instead the content teaching took place almost as an aside to the major emphasis of activities.

We hypothesized that this difference in how the dominant orientation was implemented in the project would impact teacher outcomes from PD. Thus the same project rater teams were asked to further classify each project as implementing the dominant orientation in either a "continuous" or "intermittent" way – as described above. We then examined the relationship between the combination of orientations and the continuous/ intermittent rating and PD outcomes.

## *Results and Interpretations*

In this section, we present our results organized by research questions. Once again, our research questions were:

1. What are the orientations of the 14 projects and how do teacher participants' perceptions of their projects align with researcher ratings?
2. Are there differences in project outcomes based on orientation and how consistently the orientations are implemented in teacher self-reported ratings of:
    - Impact on teaching practices?
    - Contributions of PD aspects to teaching practice?
    - Teacher confidence in subject matter and teaching knowledge?

### *Research Question 1: PD Orientations and Participant Perceptions*

A new orientation emerged through data analysis beyond those established by Authors (in review). This orientation *Balance -- Science/Mathematics Content and Pedagogy* is characterized as helping teachers to learn the science/mathematics content in tandem with learning appropriate pedagogical strategies, demonstrating a balance of characteristics of *both* the "content-driven" and "pedagogy-driven" approaches, but often in an integrated form. This orientation was proposed by one researcher early in the rating process. We then added this orientation and definition to the rating list and raters applied it to other projects as appropriate.

Project orientations ratings (Table 2) showed the majority of projects distributed amongst the *activity* (4), *content* (3) and *pedagogy-driven* (5) orientations with two projects rated as *balanced*. Although two projects exhibited some characteristics of the *curriculum materials* or *needs* approaches, these approaches were not the major foci of any of those two projects and thus did not constitute their dominant orientation. Note that of the 14 projects, we rated six as "continuous" (demonstrated a consistency in orientation across project activities) and eight as "intermittent" (demonstrated inconsistency in orientation across project activities).

Table 2. Orientation / Linkage Distribution

| Orientation: | Activity | Content | Pedagogy | Balanced |
|---|---|---|---|---|
| # continuous/<br># intermittent: | 2/2 | 0/3 | 2/3 | 2/0 |

In order to compare the researcher ratings of the projects to the perceptions of the 14 projects' participants, we analyzed participant responses at the end of the summer institute to 12 items concerning the relative emphasis of different PD components. Exploratory factor analysis produced three factors with acceptable reliabilities (Table 3). We hoped to find support for our own ratings of the projects in participant responses to these items that also showed they observed different PD components emphasized for projects that had differing orientation ratings.

Table 3. PD Emphasis Factors

| Factor | Items | Cronbach's Alpha |
|---|---|---|
| 1. Teaching knowledge and skills | 6 | .80 |
| 2. Classroom activities and materials | 4 | .72 |
| 3. Other teaching tools | 2 | .65 |

A MANOVA ($n = 297$) with orientation and consistency as independent variables and the three PD emphasis factors as dependent variables showed a main effect for project orientation and consistency ($F(3, 293) = 9.98$, $p < .01$; $F(1, 295) = 14.46$, $p < .01$, respectively); there was no interaction between project orientation and consistency. Post hoc analysis for orientation showed several significant differences between orientations (see Table 4). Post hoc analysis are not applicable to the main effect for consistency as there are only two levels for the independent variable, however for all three factors projects exhibiting a continuous orientation delivery had higher means than those of intermittent projects.

Table 4: Post Hoc Analysis –PD Emphasis by Orientations

| Emphasis Factors | Differences by Orientation | | Mean Difference | Std. Error | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|---|---|---|
| Teaching knowledge and skills | Balanced | Activity | 0.30** | 0.09 | 0.12 | 0.48 |
| | Balanced | Pedagogy | 0.31** | 0.09 | 0.14 | 0.48 |
| | Content | Activity | 0.21** | 0.08 | 0.05 | 0.37 |
| | Content | Pedagogy | 0.22** | 0.08 | 0.07 | 0.37 |
| Classroom activities and materials | Activity | Pedagogy | 0.16** | 0.06 | 0.04 | 0.28 |
| | Balanced | Pedagogy | 0.18** | 0.07 | 0.05 | 0.32 |
| Other teaching tools | Activity | Balanced | 0.40** | 0.12 | 0.17 | 0.63 |
| | Activity | Pedagogy | 0.39** | 0.10 | 0.20 | 0.58 |
| | Content | Pedagogy | 0.36** | 0.10 | 0.17 | 0.55 |
| | Content | Balanced | 0.37** | 0.12 | 0.14 | 0.60 |

* $p < .05$ , ** $p < .01$

For Factor 1 (teaching knowledge and skills), participants in projects rated as *balanced* (*M*=2.6; *SE*=.07) and *content* (*M*=2.5; *SE*=.06) reported significantly greater emphasis for the survey items related to this factor than participants in projects rated as *activity* (*M*=2.2; *SE*=.06) and *pedagogy* (*M*=2.2; *SE*=.05). For Factor 2 (classroom activities and materials), participants in projects rated as *balanced* (*M*=2.8; *SE*=.06), *activity* (*M*=2.7; *SE*=.05), and *content* (*M= 2.7; SE=.05*) reported significantly greater emphasis on the survey items related to this factor than participants in projects rated as *pedagogy* (*M*=2.6; *SE*=.04). For Factor 3 (other teaching tools), participants in projects rated as *activity* (*M*=2.6*; SE*=.07*)* and *content* (*M*=2.6*; SE*=.08) reported significantly greater emphasis on the survey items related to this factor than participants in projects rated as *balanced* (*M*=2.2*; SE*=.09) and *pedagogy* (*M*=2.2*; SE*=.06).

These data show that participants in projects of differing orientations did perceive that their projects emphasized different PD aspects, and in many cases significantly. We as researchers analyzed a corpus of data sources and assigned each of the 14 projects with a distinct, dominant orientation. The factor analysis of the survey items that addressed PD project emphasis and follow-up post-hoc analysis indicates that participants agreed with the researcher ratings. For example, our results from Table 4 show that when considering survey questions grouped into

Factor 1 (teaching knowledge and skills), it makes sense that participants in *balanced* projects (where the focus is both on content and pedagogy) would report greater emphasis on items related to teaching knowledge and skills than those participants in *activity* projects.

Although post hoc analyses are not applicable to the main effect for consistency as there are only two levels for the independent variable, we did observe that a project's consistency rating resulted in statistically significant differences for Factors 1 and 3. Participants in projects rated as "continuous" ($M$=2.5; $SE$=.04) reported greater emphasis in items regarding teaching knowledge and skills (Factor 1) than those participants in projects rated as "intermittent" ($M$=2.2; $SE$=.04). A similar relationship exists for Factor 3 (other teaching tools) with "continuous" project participants ($M$=2.5; $SE$=.05) reporting greater emphasis than "intermittent" project participants ($M$=2.3; $SE$=.06).

Given both the main effects for orientation, and consistency in conjunction with the post hoc analysis effects for orientation we found that participants distinguished significant differences between the emphasis areas of these projects that can be accounted for by the orientation and consistency variables that we as researchers applied. Thus, for RQ1 we conclude that the participant data on these factors provide support that the orientations ratings that we applied do indeed account for perceived differences in project emphases from the participants' view, and that our ratings in alignment with the perceptions of project participants.

*Research Question 2: Outcomes as Related to Orientations / Consistency*

*Relation of Improved Teaching Practice to Orientations/Consistency.* At the end of the summer institute, teachers rated their perceptions of how their teaching practices would improve in the coming year due to PD. Teachers responded to 12 items such as potential improvements in content knowledge or increasing student motivation on a four-point scale from "none" to "very much." An exploratory factor analysis for these items produced a single factor with .92 reliability coefficient.

An ANOVA (n = 292) with orientation and consistency as independent variables and the single factor for teaching practice as the dependent variable showed a main effect for project orientation ($F$(3, 289)= 7.9, $p$ < .01) and a main effect for consistency ($F$(1, 290)= 4.0, $p$ < .05); there was no interaction between orientation and consistency. Post hoc analysis showed several significant differences between orientations (see Table 5) for this factor. Participants from projects exhibiting a *balanced* orientation reported they intended to make significantly more improvements in teaching practices ($M = 2.6$, $SE = .3$) than did respondents in projects exhibiting either an activity or pedagogy orientation (Significance .001 and .000 respectively). Similar results were found for the content orientation relative to participants' plans to improve teaching practices. Participants from projects exhibiting a *content* orientation reported they intended to make significantly more improvements in teaching practices ($M = 2.5$, $SE = .4$) than did respondents in projects exhibiting either an *activity* or *pedagogy* orientation ($M = 2.3$ for both) (Significance .014 and .001 respectively).

Table 5: Post Hoc Analysis –Significant Differences Between Orientations For Teaching Practice Improvement

| Orientation | Differences by Orientation | Mean Difference | Std. Error | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|---|---|
| Balanced | Activity | 0.32** | 0.10 | 0.13 | 0.51 |
| Balanced | Pedagogy | 0.38** | 0.09 | 0.20 | 0.55 |
| Content | Activity | 0.21** | 0.09 | 0.04 | 0.38 |
| Content | Pedagogy | 0.27** | 0.08 | 0.11 | 0.46 |

* p < .05 , ** p < .01

Participant responses on the improvements in their teaching practices varied statistically by orientation; in particular it appears that at the end of the summer institute, participants in projects rated as either *balanced* or *content* focused perceived that their teaching practices would be improved more so than participants in projects rated as either *activity* or *pedagogy.* Although post hoc analyses were not appropriate, the means for projects with a continuous rating were higher than those for projects exhibiting an intermittent rating (2.5 as compared to 2.3).

*Relationship between Perceived Contribution to Professional Practice from Aspects of PD and Orientations/ Consistency.* Another participant outcome we examined was teachers' perceptions at the end of the PD project of how five different aspects of PD (see Table 6 for these aspects) contributed to their practice as teaching professionals. Teachers rated each of the PD aspects in terms of its contribution to their professional practice during the academic year they were just completing on an 11-point scale where zero indicated "none" and ten indicated "very much".

We then analyzed the relationship between these responses and PD orientation. A MANOVA ($n$ = 217) with orientation and consistency as independent variables and the five professional practice items as dependent variables showed a main effect for project orientation ($F(3, 213)$= 2.182, $p < .01$); there was no main effect for consistency and no interaction between orientation and consistency. Post hoc analysis showing several significant differences between orientations is summarized in Table 6.

| Activities/time spent on… | Differences by Orientation | | Mean Difference | Std. Error | 95% CI Lower Bound | 95% CI Upper Bound |
|---|---|---|---|---|---|---|
| Content knowledge | Content | Activity | 0.85* | 0.42 | 0.01 | 1.68 |
| | Balanced | Activity | 1.31** | 0.46 | 0.41 | 2.21 |
| Pedagogy | Balanced | Activity | 1.04** | 0.39 | 0.27 | 1.81 |
| | Balanced | Content | 0.88* | 0.42 | 0.06 | 1.70 |
| | Balanced | Pedagogy | 0.87* | 0.38 | 0.12 | 1.63 |
| Instructional Materials | Content | Activity | 0.81* | 0.37 | 0.09 | 1.53 |
| Assessment | Pedagogy | Activity | 0.70* | 0.33 | 0.04 | 1.36 |
| | Content | Activity | 1.20*** | 0.38 | 0.46 | 1.94 |
| | Balanced | Activity | 1.27** | 0.41 | 0.47 | 2.07 |
| Communication/ collaboration with teachers | Balanced | Activity | 1.05* | 0.45 | 0.17 | 1.93 |
| | Balanced | Pedagogy | 1.14* | 0.43 | 0.28 | 2.00 |

Table 6: Post Hoc Analysis –Perceptions of Aspects of PD Impact on Professional Practice
*p < .05 , ** p < .01

Table 7 shows the means by orientation for each of the aspects of PD that may have impacted professional practice. These data together with the data in Table 6 provide evidence that these aspects of PD had varying perceived impact on professional practice based on which orientation a project exhibited.

Consistent with the results from Table 5 (impact on teaching practice), the *balanced* and *content* orientations appeared to have a stronger impact than did projects exhibiting an *activity* or *pedagogy* orientation. For instance, participants in *balanced* projects experienced multiple PD aspects (e.g. content knowledge, pedagogy, assessment and communication) as contributing significantly more to their teaching practices than participants in other orientations. Participants in projects rated as having *content* (*M*=7.4; *SE*=0.32) reported that the project emphasis on content knowledge had a statistically significantly greater impact on their professional practice than the participants in projects rated as *activity* (*M*=6.5; *SE*=0.28). For the content knowledge emphasis area, however, participants in projects rated as *balanced* reported the highest means of the four orientations (*M*=7.8; *SE*=0.37), although this mean was only statistically significantly greater than the responses from participants on their professional practice in projects of one other orientation -- the *activity* (*M*=6.5; *SE*=0.28) orientation. The balanced responses, however, also approached a significantly higher level than those from the pedagogy project (p < .10).

Table 7. Means by orientation for Impact on Professional Practice

| Orientations / Aspects of PD | Activity | Content | Pedagogy | Balanced |
|---|---|---|---|---|
| Content Knowledge | 6.5 | 7.4 | 7.0 | 7.9 |
| Pedagogy | 7.3 | 7.5 | 7.5 | 8.4 |
| Instructional Materials | 7.3 | 8.1 | 7.6 | 8.1 |
| Assessment | 6.4 | 7.6 | 7.1 | 7.7 |
| Communication | 7.4 | 8.1 | 7.3 | 8.4 |

*Teacher Confidence as Related to Orientations / Consistency*
At the end of the PD project, we asked teachers to indicate their changes in confidence in science/mathematics content knowledge and their teaching knowledge as a result of PD. Teachers responded on a 4-point scale.

We conducted a Chi square analysis between orientation and ratings of domain and teaching confidence where respondents indicated how much confidence improved on a four-point scale from "not at all" to "very much". We found no significant relationships. We did not include the “consistency” characteristic in the analysis in order increase cell frequencies. Thus for this data set, there was no difference between participants’ confidence in domain or teaching knowledge based on the orientation of their project.

## *Discussion and, Conclusion*

This research produced several noteworthy results both in terms of creating a new framework for understanding PD projects and relating this framework to characteristics for PD that may prove to provide the most beneficial experience to participants.

This research confirms that PD orientations exist, as established in our prior work (Park Rogers, et al., 2008). The teachers who participated in these PD projects reported differing outcomes by orientation, thus confirming the researchers’ ratings of projects as having different orientations. Further, this research established a new orientation -- *balanced* -- defined as projects that support teachers to learn the science/mathematics content in tandem with learning appropriate pedagogical strategies, demonstrating a balance of characteristics of *both* the “content-driven” and “pedagogy-driven” approaches, but often in an integrated form.

In addition, we posit that this research strengthens the concept of there being an orientation to PD by establishing a consistency rating -- continuous or intermittent -- to describe the ways in which projects displayed their dominant orientation throughout the project. For our first research question, the consistency rating, for instance, added further evidence to support that participant ratings of project emphasis did vary not only by PD orientation but also by whether a project was rated as continuous or intermittent. Additionally for research question two, we determined a main effect for the consistency variable with projects that were continuous having higher means for teaching impact than intermittent projects. Although this evidence is preliminary, it does provide support for the intuitive idea that when the PD orientation is implemented consistently throughout the project, participant outcomes might be stronger.

The *balanced* orientation characterizes PD committed to enhancing both pedagogical knowledge and mathematics and/or science content knowledge. The *balanced* orientation of PD reflects the current view of the intertwining nature of content knowledge and pedagogical knowledge referred to as pedagogical content knowledge (PCK) (Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Shulman, 1986;1987). PCK is defined as transformed knowledge of content that intertwines knowledge of learners, instructional strategies, assessment, and curriculum. For example, an algebra teachers' PCK would include knowledge of student misconceptions about the meaning of variables, appropriate instructional strategies and curriculum materials for teaching about the meaning of variables, and strategies for assessing students' understanding of this topic. PD that provides a *balanced* perspective focuses on content knowledge and pedagogical knowledge simultaneously rather than providing a false separation of these knowledge types. The effectiveness of balancing both content and pedagogy in PD has been established by prior studies (e.g., Blank, de las Alas, & Smith, 2008) and is the basis of several policy recommendations with regard to PD for mathematics and science teachers (e.g., NCTM 1991; NSCD, 2001). Further, Darling-Hammond and her colleagues (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2008), in a review of the PD literature, state, “Effective professional development…focuses on the teaching and learning of specific academic content” (p. 5).

The 14 PD projects demonstrated four orientations to PD design and delivery and were nearly evenly mixed between continuous and intermittent consistency ratings. Much has been written about the many factors that professional developers need to consider when designing a PD experience to be effective (Loucks-Horsley et al., 2003). However, there is little discussion on how professional developers should conceptualize and enact their designs to ensure desirable PD outcomes. We propose that the application of this orientations framework may provide such guidance. As such, these orientations and consistency ratings offer professional developers, developers of professional developers, and researchers a new framework through which to consider their work. For professional developers, these orientations can be used in the design and implementation of effective PD for mathematics and science teachers. For example, the 14 projects in this study had leadership teams, composed of content specialists, education faculty, and district-level teachers and administrators. Viewing PD through an orientations lens could facilitate conversation and decision making in such leadership groups. For those who work with mathematics and science education doctoral students in educating them to be professional developers, this orientations lens can enhance their understanding of effective PD and the influence that PD designers can have on PD outcomes. Orientations tend to be tacit in nature. As such, this orientations framework makes explicit factors that can have an impact on PD outcomes and can facilitate conversations around the goals and purpose of professional development.

Furthermore, the PD orientation framework provides a new tool for researchers to analyze the design and implementation of PD. As described in the literature review, previous research has found that PD outcomes are 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 orientations framework represents not a single one-dimensional variable but a holistic way to look at PD projects that encompasses the beliefs of PD developers as well as how they implement their projects. This more complex framework can then be related to various PD project outcomes. We believe that this framework adds to the work begun by Desimone et al. (2002) that allows PD researchers to examine PD in ways that account for the complexity of PD design and implementation.

Although our work is preliminary – this is the first application of the PD orientations framework to PD outcomes – our initial results are encouraging both in terms of the value of the framework (teacher ratings of PD emphasis areas confirmed differences in projects by orientations), and the differences we found between PD outcomes by projects exhibiting different orientations. For the latter result we found in particular that the *balanced* approach to PD consistently showed stronger outcomes than other approaches (Tables 5 - 7), a finding that supports an extensive evaluation of 25 PD projects in 14 states conducted with support of the Council of Chief State School Officers [CCSSO] (Blank, de las Alas, & Smith, 2008). Blank and his colleagues stated:

> The cross-program review of studies showed significant effects of professional development programs for teachers of math and science when the programs include a focus on content knowledge in the math and science subject areas plus training and follow-up pedagogical content knowledge. (p. 26)

We recognize that PD is complex and that other factors also influence PD outcomes. For example, the consistency in focus on PD within a school or district can impact the extent to which changes are made to teachers' instructional practices (Darling-Hammond, et al., 2008). Other *individual* factors have also been linked to effective PD (see literature review). The strength of using an orientations lens as a factor for assessing PD outcomes, however, is that it supports a more holistic approach to evaluating PD for mathematics and science teachers, allowing professional developers and researchers to consider projects *as a whole* instead of as a sum of individual factors.

Finally, the *content* and *balanced* orientations were linked to a greater impact on instructional practices and professional practices than were the *activity* and *pedagogy* orientations (see Tables 5 - 7). Teachers may have felt that the emphasis on content, as evident in both the *content* and *balanced* orientations, had more impact on their instruction because approximately two-thirds of the teachers participating in the PD projects were certified in early childhood and elementary--certification areas that generally have little emphasis on mathematics and science content. In other words, were teachers more satisfied with projects that focused on potential weaknesses in their understandings of mathematics and science content? Further research is necessary to determine the relationship between orientation and the impact on teacher instructional practices with other teacher populations.

The application of “orientations” to examining PD outcomes provides a new tool for understanding the characteristics of PD projects that may impact effectiveness. This study has confirmed that these orientations apply to a diverse set of projects, and further that ratings from participants in *projects exhibiting different orientations* confirm different areas of PD that are being emphasized (RQ1), as well as report significantly different PD outcomes (RQ2). Thus the significance of this study lies in applying theory-based framework to PD projects to explore the forces that influence the outcomes of PD.

**References**

Abell, S. K., & Bryan, L. S. (1997). Reconceptualizing the elementary science methods course using a reflection orientation. *Journal of Science Teacher Education, 8*, 153-166.

Abell, S., Ehlert, M., Lannin, J., Marra, R., & Arbaugh, F. (2007). Evaluation of Professional Development Projects: Cycle 4 External Evaluation Report Executive Summary. Retrieved 24 July http://www.pdeval.missouri.edu/docs/cycle4/Cycle%204%20Executive%20Summary.pdf

Abell, S. K., Lannin, J. K., Marra, R. M., Ehlert, M. W., Cole, J. S., Lee, M. H., Park Rogers, M. A., & Wang, C. (2007). Multi-site evaluation of science and mathematics teacher professional development programs: The project profile approach. *Studies in Educational* Hill, Ball, & Shilling *Evaluation, 33*, 125-158.

Anderson, C. W., & Smith, E. L. (1987). Teaching science. In V. Richardson-Koehler (Ed.), *Educators' handbook: A research perspective* (p. 84-111). New York: Longman.

Banilower, E.R., Heck, D.J. & Weiss, I.R. (2007). Can professional development make the vision of the standards a reality? The impact of the National Science Foundation's local systemic change through teacher enhancement initiative? *Journal of Research in Science Teaching, 44*(3), 375-395.

Barrett, S. E., & Pedretti, E. (2006). Contrasting orientations: STSE for social reconstruction or social reproduction? *School Science and Mathematics, 106*, 237-247.

Blank, R. K., de las Alas, N., & Smith, C. (2008). *Does teacher professional development have effects on teaching and learning? Analysis of evaluation findings from programs for mathematics and science teachers in 14 states*. Washington, DC: Council of Chief State School Officers.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Clarke, D. (1994). Ten key principles from research on the professional development of mathematics teachers. In D. B. Aichele & A. F. Coxford (Eds.), *Professional development for teachers of mathematics* (pp. 37-48). Reston, VA: National Council of Teachers of Mathematics.

Darling-Hammond, L., Wei, R. C., Andree, A., Richardson, N., & Orphanos, S. (2009). *Professional learning in the learning profession: A status report on teacher development in the United States and abroad*. Washington, DC: National Staff Development Council.

Desimone, L. M., Porter, A. C., Garet, M. S., Yoon, K. S., Birman, B. F. (2002). Effects of professional development on teachers' instruction: Results from a three-year longitudinal study. *Educational Evaluation and Policy Analysis, 24*, 81–112.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Garet, M.S., Birman, B.F., Porter, A.C., Desimone, L. & Herman, R. (1999). *Designing effective professional development: Lessons from the Eisenhower Program*: US Department of Education.

Garet, M.S., Porter, A.C., Desimone, L., Birman, B.F, & Yoon, K.S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Grossman, P. (1990). *The making of a teacher*. New York: Teachers College Press.

Guskey T. (2000). *Evaluating professional development*. Thousand Oaks, CA: Corwin Press.

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development: A new consensus. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127-150). San Francisco: Jossey-Bass.

Hill, H. C., Ball, D.L., & Shilling, S.G. (2008). Learning mathematics for teaching: Results from California's mathematics professional development institutes. *Journal for Research in Mathematics Education*, 35 (5), 330 – 351.

Horizon Research, Inc. (2000). Inside the Classroom Observation and Analytic Protocol. Retrieved 19 December 2008 from http://www.horizon-research.com/instruments/clas/cop.php.

Ingvarson, L., Meiers, M., & Beavis, A. (2005). Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes. In S. Dorn (Ed) *Education Policy Analysis Archives, 13* (10), 1-28.

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005) Characteristics of professional development that effect change in secondary science teachers' classrooms practices. *Journal of Research in Science Education, 42*(6), 668-690.

Kennedy, M.M. (1999). *Form and substance in mathematics and science professional development.* NISE brief (vol. 3, no. 2). Madison, WI: University of Wisconsin-Madison, National Institute for Science Education.

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. W. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.*)*. Thousand Oaks, CA: Corwin Press, Inc.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95-132). Dordrecht, Netherlands: Kluwer Academic Publishers.

National Council of Teachers of Mathematics (NCTM) (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Staff Development Council (NSDC). (2001). S*tandards for staff development (revised).* Retrieved July 25, 2007 from http://nsdc.org/standards/index.cfm

Park Rogers, M., Abell, S., Marra, R., Arbaugh, F., Hutchins, K., & Cole, J. (2008). Multiple approaches to science teacher professional development: What are they and how do teachers respond? Paper presented at the annual meeting of the *American Educational Research Association*. New York, New York, March 25 - 29.

Park Rogers, M., Abell, S., Lannin, J., Wang, C., Musikul, K, Barker, D., & Dingman, S. (2007). Effective professional development in science and mathematics education: Teachers' and facilitators' views. *International Journal of Science and Mathematics Education, 5*, 507-532.

Shepardson, D.P., Harbor, J., Cooper, B., & McDonald, J. (2002). The impact of a professional development program on teachers' understandings about watersheds, water quality, and stream monitoring. *Journal of Environmental Education, 33*(3), 34-40.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Sowder, J. T. (2007). The mathematical education and development of teachers. In F. Lester

(Ed.), Second handbook of research on mathematics teaching and learning. National Council of Teachers of Mathematics.

Thompson, C.L., & Zeuli, J.S. (1999). The frame and the tapestry: Standards-based reform and professional development. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession. Handbook of policy and practice* (pp. 341-375). San Francisco: Jossey-Bass.

Volkmann, M. J., Abell, S. K., & Zgagacz, M. (2005). The challenges of teaching physics to preservice elementary teachers: Orientations of the professor, teaching assistant, and students. *Science Education, 89*, 847-869.