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ABSTRACT

Professional development that aims to transform teaching and build substantial knowledge of science and mathematics content is not a simple task of "design and implement"; rather, it involves remaining alert to the changing context in which professional developers are working, the stages of development teachers move through as they develop new knowledge and skills, and a host of other dynamics at work. Four case studies of professional development are synthesized in this report which discusses those decision points or dilemmas common to the cases. Professional development decisions related to philosophical versus pragmatic focus, depth versus breadth of the teacher target audience, and adoption versus development of curriculum are discussed. A framework for planning and analyzing professional development programs is also presented. (WRM)

NISE BRIEF

REPORTING ON ISSUES AND RESEARCH IN SCIENCE, MATHEMATICS, ENGINEERING, AND TECHNOLOGY EDUCATION

Designing Professional Development for Science and Mathematics Teachers: Decision Points and Dilemmas

By Susan Mundry and Susan Loucks-Horsley[1]

Effective professional development benefits teachers and students alike.

Professional developers face a number of key decisions and dilemmas as they design and carry out learning opportunities for teachers. Professional development that aims to transform teaching and build substantial knowledge of science and mathematics content is not a simple task of "plan and implement." Rather, it involves staying alert to the changing context in which professional developers are working, the stages of development teachers move through as they develop new knowledge and skills and a host of other dynamics at work.

To learn more about professional development design and implementation across diverse sites, the NISE professional development project team conducted a series of case studies. The case studies examine professional development in different stages of design and implementation, different grade levels,

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subject matter, units of change (e.g., district, school), and in settings with contrasting demographics. The cases focus on how professional developers think about and apply the different inputs to professional development design as they conduct their work.

The studies examined four cases of professional development—two focused on mathematics, one on science and mathematics, and one on science and technology education. Three of the case studies were in urban, culturally diverse settings; the fourth was in a large rural region with 42 schools participating in a professional development initiative. Two of the case studies were retrospective analyses of schools involved in a completed multiyear reform project. One case study analyzed districtwide professional development at the planning stage. The fourth case study examined professional development design in the middle of a five-year reform initiative. The names used here are pseudonyms. (The characteristics of study sites are displayed in Table 1.)

The examination of these sites revealed how dynamic professional development is and what challenges professional developers face as they design and implement teacher learning programs. Case writers saw great value in looking at professional developers' practice in terms of the decisions they make and dilemmas that they face. (By dilemmas the case writers mean those situations that arose that caused professional developers to make difficult choices—often unconsciously and between unattractive alternatives—as they developed their designs and carried out their work.)

As Hewson (in Loucks-Horsley et al., in press) writes: "Since the essence of design is combining knowledge and expertise of various kinds to produce a unique solution within a specific context, the need to consider the pros and cons of different perspectives of the design provides fertile ground for producing dilemmas." The case studies underscore the importance for those who plan and implement teacher learning activities to assess their progress at many points along the way, acknowledge the dilemmas and decision points that emerge for them, and communicate decisions and rationale with others to build and maintain commitment.

There were several decision points or dilemmas encountered in the cases that are common to many professional development situations. Three are discussed below.

Focus of the Professional Development—Philosophical or Pragmatic?

One dilemma is whether to focus professional development on philosophical issues, such as changing teachers' views of learning, or to focus on more pragmatic issues, such as the use of specific instructional approaches and curriculum materials and how use shifts over time for teachers and professional developers.

In the Riverside Middle School case, the professional developers and the teachers held different perspectives of the focus of the professional development at different points in time. The professional developers started with the intent of focusing on philosophy of teaching mathematics; their approach later

For further information on these ideas and discussion of other dilemmas and decision points encountered by professional developers in the case study sites see: Loucks-Horsley, S., Hewson, P. W., Levine, N., Mundry S., Silver, E., Smith, M., Stein, M. K., & Stiles, K. (in press), *Case studies of professional development design for teachers of science and mathematics.* Madison, WI: National Institute for Science Education.

Table 1. Characteristics of Cases Included in the Study[2]

Characteristics	Brantley	Cornerstone	Franklin	Riverside
Subject Matter	Science & Mathematics	Science and Techonology	Mathematics	Mathematics
Grade Level	K-12	K-8	6-8	6-8
Location	Urban	Rural	Urban	Urban
Site for Professional Development	School District	Geographic Region w/ 42 schools	Single School	Single School
Student Characteristics (Two largest groups)	Diverse (Hisp./Cauc.)	Diverse (Cauc./Nat.Amer.)	Diverse (African Amer/Hisp.)	Diverse (Cauc./African Amer)
Stage of PD	Planning	Year 2 of 5-year Effort	Completed 5-year Effort	Completed 5-year Effort

became more pragmatic in response to the context and the teachers' needs. Two years into the project, Riverside teachers wanted to focus on pragmatic concerns such as planning lessons, developing assessments tied to the new curriculum, and communicating with parents. The professional development providers, on the other hand, wanted to keep the focus on philosophical issues, such as learning theory and evidence of children's learning.

The Riverside case suggests a program guided solely by practical issues lacks a vision for program improvement. A program guided solely by philosophical issues ignores the realities of teachers' lives. The case teaches the importance of maintaining a balance between a practical and philosophical perspective, with the understanding that at different times in the process professional developers might focus more on one or the other, but that neither is sufficient alone.

This case points out a common dilemma for professional developers—how to maintain a focus on changing the philosophy of teaching and learning, while being responsive to teachers' needs for help with specific strategies and implementation issues. As the Riverside case authors note, "The inability to balance or integrate...alternative perspectives at either time point" may have led to a less successful professional development program.

The Brantley case presents another example of this dilemma, this time at the school district level. In this case a district professional development planning team sought to promote teaching consistent with the National Science Education Standards (National Research Council, 1996). To do so, the team needed to engage teachers in professional development that would build new views of teaching and learning. However, the previous professional development had been more practically focused.

As team members worked to establish this new focus for the district's professional development program in science, they realized that administrators and some teachers in the district expected professional development to be

The ultimate goal of all professional development is improved student achievement.

adoption and training in specific curriculum materials. These expectations presented a dilemma to the planning team. While they decided to shift the focus of professional development beyond pragmatic curriculum implementation issues, they pursued this goal knowing that their decision was out of alignment with the context.

The infrastructure was not in place to support the kinds of professional development needed for this broader, more philosophic approach. For example, the schedule and structure did not provide the flexibility for teachers to engage in reflection on their practice or in collegial interaction, nor for them to initiate and direct their own professional learning. Instead, they were taking part in workshops on how to implement curriculum, with little opportunity for indepth follow-up learning.

The team determined that the professional development plan should include strategies, other than workshop sessions, that give teachers opportunities to engage with research on learning and reflect on practice. Before the planning team could shift the focus of the professional development to include new views of teaching and learning as described in the National Science Education Standards, they needed to initiate changes in the culture and infrastructure to support their more philosophical goal. Team members would need to begin to think about professional development not just as workshops, but also as instances of teachers working together to examine practice and exchange ideas about teaching. Thus they would come to value collegiality among teachers and teacher expertise.

These examples suggest that with regard to the focus of professional development it is important to:

- Maintain a balance between philosophic and pragmatic approaches and be responsive to changing teacher needs and the dynamic school context.
- Gain agreement among participants about the focus for the professional development and continually assess that the focus is on track as the professional development initiative proceeds.
- Build the professional development infrastructure (funding, schedule, and varied professional development strategies) to support both philosophically and programatically focused professional development.

Audience—Fewer Teachers in Depth or Every Teacher?

Should staff developers try to design an intervention to reach all teachers, or one that works in more depth with fewer teachers? In recent years professional developers have been challenged to "scale up" their interventions to reach all teachers. The case studies reviewed here suggest that professional development programs need special features to reach all teachers. It is not simply a matter of providing everyone with the same experience. The strong influence of context in all the cases suggests that learning experiences vary greatly from teacher to teacher and setting to setting.

In the Franklin case, the goal was to promote schoolwide change among all of the

Professional development must strike a balance between imparting a philosophy of learning and meeting the day-to-day needs of teachers in classrooms.

mathematics teachers. After just two years of the project, about half of the teachers initially involved had left the school or were teaching in another grade or subject. By the midpoint of the project just 20 percent of the original teachers remained. Responding to this common urban phenomenon of high teacher mobility, the professional developers at Franklin altered their design. They recruited the "more experienced and able teachers" to perform curriculum and assessment design work. Less experienced teachers were invited to meetings and asked to implement what their colleagues designed. By devoting intensive amounts of time and energy to a few teachers, the professional developers felt that attaining deep-seated, real change in practice was possible.

However, this approach to professional development created problems. Giving responsibility for curriculum development to just a few teachers limited the opportunities for others to fully participate and build their knowledge.

In the Brantley case the goal was to reach every teacher, yet Brantley's thousands of teachers ranged widely in the extent to which they were using curriculum materials required by the district and how well they were doing so. The dilemma created by the goal to reach all teachers was how much emphasis (and therefore how many resources) to place on moving teachers beyond mechanical use of the instructional materials, and how much to focus on orientation inservices for teachers who had not yet implemented the instructional materials. The district was trying to do both, by offering a potpourri of workshop choices, thus haphazardly offering professional development opportunities that were neither linked nor cohesively connected.

To reach all teachers, professional developers need both a materials infrastructure and a human infrastructure within the context that they work. The material infrastructure is the "articulated foundation of what the requested change entails, such as clear direction, a reform curriculum, and vision. The human infrastructure is the culture for learning and reform that is established in the school or district that encourages a community of practice to develop" (Loucks-Horsley et al., 1998, p. 38).

The case studies suggest that:

- Working successfully with all teachers requires that the schools/districts have an articulated culture for change and available resources, including knowledge/expertise and time for teacher learning.
- Professional developers need to hold high standards for teacher learning and be clear about the goals. They must work to build a shared commitment among teachers to reach the high standards. Watering down standards or allowing wide variety in approach in order to include all teachers results in uneven implementation and unclear practices.
- A process for rolling admission to professional development initiatives is necessary to involve new or reassigned teachers, especially in urban settings where turnover is high.

Curriculum—Develop or Adopt?

A common goal of reform initiatives in science and mathematics education is to provide students with opportunities to learn using quality, standards-based curriculum materials. A critical decision in the design of professional development is whether to engage teachers in curriculum development or help them learn to use existing curriculum materials. In the case of the Cornerstone site, the strength of local rule required the project to develop many options for the districts participating in the project. The project organizers believed that if they required districts to adopt a new curriculum, the districts would not participate.

This decision was problematic for several reasons. First, by trying to provide enough flexibility of curriculum choices for everyone, the vision of teaching and learning for the project became diluted. At one end of the spectrum were participating teachers who chose to try out one unit or one activity. At the other end were teachers who tried

to develop a yearlong curriculum from the many activities or units they experienced during workshops and summer institutes. They cobbled together a set of instructional materials and strategies, without careful thought about how the pieces joined to provide coherent learning experiences for students.

The assumption of the professional developers was that once teachers experienced pieces of curriculum, they would make good choices about what to use in their own classrooms. Their approach relied on teachers' ability to set meaningful learning goals and put together the right combination of units. Unfortunately, most of the teachers did not have the time, resources, or skills to carry this out.

In the Franklin case, the professional developers also viewed teachers as curriculum developers. They believed that teachers would translate general ideas, principles, and research findings to create their own classroom materials. Case authors wrote: "Those who argue that teachers should develop their own curriculum claim that it makes teachers more attuned to students' needs, that it promotes ownership over the academic program by teachers, and that the process of curriculum development can be an incredibly powerful professional development experience for teachers." However, in this case, as in the Cornerstone case, teachers lacked the time and content knowledge needed to translate reform ideas into practice and build a "meaningful and coherent" curriculum.

The Riverside school, in contrast, chose to adopt an existing curriculum. The teachers in this school focused their attention on learning and applying the mathematics curriculum and content within it rather than developing curriculum. They had opportunities to learn mathematics in ways that students learn it, to try out different units and discuss their results. They had regular on-site help to assist them as they used the new curriculum materials. Their students achieved significant increases in learning.

Professional developers must weigh carefully the costs and benefits of curriculum development over curriculum adoption or adaptation. When the Franklin Middle School started its mathematics reform, there were few middle school curriculum materials that reflected the standards established by the National Council of Teachers of Mathematics. Today, there are more choices of mathematics and science curriculum materials that prepare students to meet high standards. Professional developers can provide a service by helping educators choose quality curriculum and by planning how to direct the available resources to effective curriculum implementation rather than curriculum development.

The case studies suggest:

- When curriculum implementation is a goal, professional developers should help teachers review and select curriculum materials that are a good fit for their context, instead of engaging teachers in curriculum development.
- If full-scale curriculum adoption is not possible but revised curriculum is desired, create opportunities for teachers to engage in their own learning of science and mathematics through specific supplementary activities and/or curriculum replacement units. Provide help to teachers as they decide how to use the new materials in the classroom, Make sure there is an opportunity for teachers to reflect on the experience with other teachers and staff developers.
- If the decision is to engage in curriculum development or adaptation, make sure that teachers have the content knowledge needed to translate reform ideas into specific and coherent curriculum, and that they have ample time to develop, test, and refine the curriculum materials.

Coherent learning experiences for students are rooted in coherent learning experiences for teachers.

Framework for Planning and Analyzing Professional Development Programs

The case studies also support other findings from the NISE. In their study of effective professional development for science and mathematics teachers, Loucks-Horsley, Hewson, Love, and Stiles (1998) learned that outstanding professional development is

complex, combines different elements and strategies at different times, and is continuously evolving and changing. There are no exact models that can be taken and applied from place to place. Instead, there are design elements that must be considered as one plans and provides professional development for different contexts.

For example, the Franklin and Riverside cases were participating in the same national project, QUASAR, yet the designs in each site played out very differently. Such context-dependent professional development requires professional developers to have different skills and abilities than they have needed in the past. These include being able to:

- Assess the context within which they are working.
- Draw upon the knowledge base on standards-based learning and teaching of science and mathematics, professional development, and educational change.
- Work with local clients to design and/or tailor the professional development program.
- Gather data, reflect on results, and make program improvements.

The Professional Development Design Framework (Loucks-Horsley et al., 1998) displayed in Figure 1 captures this dynamic process of professional development design. The framework suggests that planning and implementing effective professional development for science and mathematics teachers requires ongoing reflection, decision making, and adjustments. Effective professional development programs are ones that are designed specifically to address a number of elements, including goals and purposes, knowledge bases, and the context within which professional development will take place. Successful professional developers consider these elements as important "inputs" to the professional development design. Further, they plan for the design to change over time to keep pace with changes in the environment and teachers' learning goals.

As professional developers work with teachers of science and mathematics, they encounter changing circumstances that demand decisions and often pose dilemmas. The case studies examined here suggest that effective professional development requires ongoing, context-related decisions and attention to the process of setting goals, planning, doing, and reflecting as depicted in Figure 1.

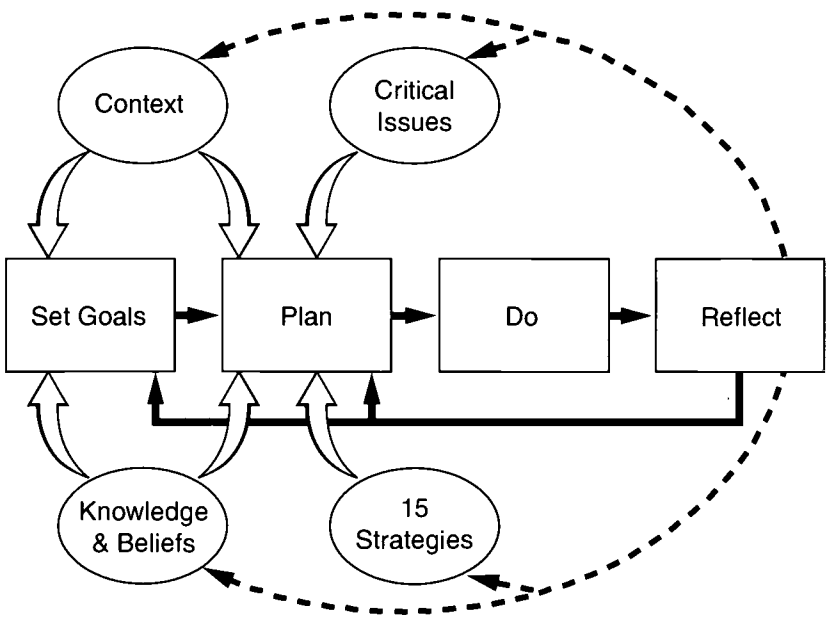

Figure 1. The Professional Development Design Framework (Loucks-Horsley, et al., 1998)
Professional development is not a simple process of "plan and implement." Rather, it is a complex process of continual reflection and adjustment. The framework in Figure 1 can help tease out the often dichotomous positions that present themselves. It can be used to surface key decision points and dilemmas that emerge in the course of teacher learning, and enhance our understanding of the tensions with which professional development designers struggle as they create learning opportunities for teachers.

Summary

Professional developers must strike a balance between philosophic and pragmatic approaches, with an emphasis on one or the other at different points in the process as circumstances dictate. Teachers need to understand what the current focus is, and why. Professional developers must also make sure that the infrastructure (funding, professional development strategies, training cycle) is in place to support that focus.

Professional developers who aim to reach all teachers need to consider whether there is a strong and clear culture for change and available resources, expertise, and time for all teachers to learn. They must work to make the goals of professional development shared by all teachers and must expect everyone to meet the goals, avoiding watered-down versions of practice as a means to reach all. Professional development programs for all teachers also need to have a process for rolling admission to continuously reach new teachers.

While curriculum development can be a valuable professional development strategy, teachers rarely have the time and resources available to them to engage productively in this activity. In settings where the considerable resources, knowledge, and time needed

for development are not available, professional developers should consider curriculum adoption or adaptation of existing materials instead.

Based on the cases and the Professional Development Design Framework presented here, we suggest that professional developers become more conscious of all the decisions they make and the impact those decisions have on the implementation of professional development. It is productive for professional developers to actively identify and reflect on the decision points and dilemmas they encounter and to devise contingency plans for changing their approach when their initial assumptions prove wrong.

The case studies–and the decision points and dilemmas they posed–suggest that effective professional developers assess their changing circumstances and contexts–and make adjustments in plans based on the best available information, staying alert to new changes that are ever-present in education reform. ***

ENDNOTES

[1] This brief is a summary of material from four case studies and a cross-case report developed by Peter Hewson, Ned Levine, Susan Mundry, Edward Silver, Margaret Smith, Mary Kay Stein, and Katherine Stiles, staff and Fellows for the NISE Professional Development Project, 1997–98.

[2] Case sites were chosen on the basis of the characteristics in Table 1 and also because sites had detailed information available (e.g., research and evaluation reports) and could provide ready access to people involved in planning and participating in professional development.

[3] For examples see Loucks-Horsley, Hewson, Love, & Stiles, 1998.

[4] National Institute for Science Education Fellows Hubert Dyasi, Susan Friel, Judy Mumme, Cary Sneider, and Karen Worth also contributed significantly to this study.

[5] Quantitative Understanding: Amplifying Student Achievement and Reasoning, funded by the Ford Foundation and directed by Edward A. Silver at the Learning Research and Development Center at the University of Pittsburgh.

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Material in this Brief is drawn from case studies written by Margaret Schwan Smith and Edward A. Silver (Riverside), Mary Kay Stein and Edward A. Silver (Franklin), Katherine E. Stiles (Brantley), and Susan E. Mundry and Ned Levine (Cornerstone), as well as a cross-case analysis by Peter W. Hewson and Susan Loucks-Horsley.

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