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ABSTRACT

This chapter presents a review of what is known from evaluation studies about the impacts of professional development programs in mathematics and science education, and their role in systemic reform. Following comparisons of program focus, structure, target population, and geographic scope, an overview of program goals is presented in terms of the following dimensions: (1) increasing teacher knowledge; (2) providing teacher renewal and the opportunity for networking; (3) increasing leadership and empowerment; (4) changing classroom practice; (5) increasing student interest and achievement; and (6) enhancing minority participation. The analysis shows that few studies have included close examination of what happens as a result of participation in professional development programs. Studies have typically focused on teacher satisfaction or other self-reported feedback. Even so, the evaluation climate has been changing, with increased emphasis being placed on evaluations that closely examine outcomes for teachers and for students, using a broader range of data gathering techniques and more robust evaluation designs. Professional development programs intended to improve teacher skills, knowledge, and practices are central to current strategies for reforming public education systems. Despite widely held beliefs that professional development programs are essential, there is little data to substantiate the impacts that such experiences make. This chapter provides an overview of what evaluation studies have told us about the efficacy of professional development as a tool for change. (Contains 40 references.) (Author/MVL)

2 What Evaluation Tells Us About Professional Development Programs in Mathematics and Science

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This chapter[1] presents a review of what is known from evaluation studies about the impacts of professional development programs in mathematics and science education, and their role in systemic reform. Following comparisons of program focus, structure, target population, and geographic scope, an overview of program goals is presented in terms of the following dimensions: 1) increasing teacher knowledge; 2) providing teacher renewal and the opportunity for networking; 3) increasing leadership and empowerment; 4) changing classroom practice; 5) increasing student interest and achievement; and 6) enhancing minority participation. The analysis shows that few studies have included close examination of what happens as a result of participation in professional development programs. Studies have typically focused on teacher satisfaction or other self-reported feedback. Even so, the evaluation climate has been changing, with increased emphasis being placed on evaluations that closely examine outcomes for teachers and for students, using a broader range of data gathering techniques and more robust evaluation designs. Professional development programs intended to improve teacher skills, knowledge, and practices are central to current strategies for reforming public education systems. Despite widely held beliefs that professional development programs are essential, there is little data to substantiate the impacts that such experiences make. This chapter provides an overview of what evaluation studies have told us about the efficacy of professional development as a tool for change.

Historical Background

Before the 1950s

To understand the context in which current teacher enhancement programs in science and mathematics are operating, it is useful to

[1]This chapter is an update of Frechtling, J., Sharp, L., Carey, N., Vaden-Kiernan, N. (1995). *Teacher Enhancement Programs: A Perspective on the Last Four Decades. Rockville,* MD: Westat.

take a brief look at changes and continuities in educational practices and priorities during the 20th century, especially since the end of World War II.

Prior to the depression era, public schooling put little emphasis on academic subjects; fewer than half of all students graduated from high school, and the number of those graduates going on to college was small. Furthermore, the majority of those who went on to the best colleges had attended private schools. For the great majority of students, and especially the masses of immigrants, most of whom were believed to be of low intelligence, the curriculum focused on "health, worthy home membership, vocation, citizenship, worthy use of leisure time and ethical character" (Kirst, 1984). A focus on academic content was absent. Instead, there was heavy public support (and federal funding) for vocational education during this period. Gradual change came about during the depression, when the lack of jobs motivated many more students to graduate from high school. The growing interest in more education suitable for the needs of all students coincided with the development of "progressive education" advocated by John Dewey and his followers, which relied on developmental theories to structure children's learning processes. According to Raizen (1993), "progressive education ... became the orthodoxy of American public schools," although it had its share of critics. And while Dewey believed that the principles of progressive education should be integrated into a strong academic curriculum, this notion did not become part of the thinking of the educational establishment in the majority of states and communities, where upper-level science and math courses were seen as "elitist" offerings. Thus, the academic component of education continued to be downgraded, and teacher training, both preservice and inservice, emphasized teaching methods and learning and behavioral theories rather than substantive academic and curriculum issues.

During this period, a parallel development was the gradual professionalization, and later unionization, of the teaching force. As the older generation of teachers (many of whom had at most a 2-year college education obtained in a teacher-training institution) were succeeded by 4-year college graduates, continuing education, which to some extent fulfills the same function as inservice training and is usually provided by academic institutions during the summer months, became a popular innovation. It exposed teachers to new knowledge and ideas, but it also subsidized the acquisition of graduate degrees by ambitious and motivated teachers. One of the earliest inservice programs was funded at Duke University, where the Duke family had specified that school teachers should be given tuition-free courses for two summers. "Since two consecutive sets of six week courses were available each summer, it was possible for teachers to satisfy two-thirds of the requirements for a masters tuition free. In 1939 and 1940, I was one of the hundreds, probably thousands of teachers who took advantage of this outstanding opportunity" (Meserve, 1989). Inservice training, whether in the form of course taking or participation in enhancement programs, continues to play an important part in furthering teachers' career opportunities to this day, whether for license renewal or promotions and salary increases.

From the 1950s to the 1980s

Between the end of World War II and the end of the cold war, the American educational system was challenged by a series of demographic, technological, political, and social developments. The diverse demands created by these developments were at times inconsistent; they also required major expenditures by state and local governments for which the federal government gradually assumed some responsibility, and they affected elementary and secondary mathematics and science instruction more than other subject areas.

Emphasis on students' academic achievement. The great increase in the demand for higher education that started with the end of World War II, when veterans attended college under the GI Bill of Rights, continued throughout this 30-year period and led to much greater emphasis on academic subjects and student achievement in high school. In earlier years, "general" or vocational education was the predominant mode in many K-12 school systems. The first initiatives to improve the academic content of the high school curriculum, especially in mathematics and science, came from industry. With the end of World War II, some influential corporate leaders, especially those at the General Electric Company (GE), began to plan for major conversions from war-time to peace-time production, which called for trained manpower in scientific and technical fields. GE officials became involved in efforts to improve the weak academic background of many high school teachers, which a review of records obtained from the New York State Department of Education had revealed. A high school teacher fellowship program was set up in 1945 at Union College, which had close ties to GE, and 40 fellows were invited to participate. Program emphasis was on academic content and lectures by prominent scientists, as well as on exposure to GE's production facilities and employment opportunities in the company (Krieghbaum & Rawson, 1969). Later, several other institutions (Case, Syracuse, Berkeley), also offered summer programs sponsored by GE. In 1952, GE launched a program at Rensselaer Polytechnic Institute for mathematics teachers, and soon programs were offered at other institutions (Purdue, Stanford) as well. When GE discontinued its summer programs for high school teachers, approximately 2,500 public and private high school teachers had participated; the total cost to GE was in excess of $1.5 million.

Westinghouse, GE's main competitor, began sponsoring a summer program for high school teachers at Massachusetts Institute and Technology (MIT), and one for guidance counselors at Carnegie Institute of Technology. Other companies also supported teacher training programs during the 1950s, including DuPont, Shell Oil, and Burroughs Adding Machines.

The emphasis on the academic content of the high school curriculum was greatly accelerated by Sputnik, the Russian space triumph, which signaled to the American public and to scientists and policymakers (especially in Congress) that the Soviet Union had equaled or perhaps outpaced America's technological leadership. It was widely believed that this had happened because the United States did not train a sufficient cadre of scientists and engineers; this in turn was partly attributed to American students' inadequate mathematics and science education. These concerns triggered the first large-scale teacher inservice programs sponsored by the National Science Foundation (NSF), the NSF institutes, which aimed at increasing teachers' scientific skills and knowledge in their fields.

From its modest beginning with a single summer institute for high school teachers in 1954, the program escalated rapidly; by 1957, over 6,500 teachers were involved, summer institutes were held in all but five states, and funding absorbed 25 percent of the total NSF budget. In 1959, NSF enlarged the program and included institutes for elementary school administrators and teachers. (Institutes for elementary administrators and teachers were discontinued in 1966.) The program continued to grow until 1965, when there were nearly 450 institutes with 21,000 high school teachers as participants. In the late sixties, the institutes reached their highest level, supporting over 35,000 participants per year; by that time, they had supported 50 percent of all secondary science and mathematics teachers (Lomask, 1975; Raizen, 1993).

The institutes were extremely popular with the Congress because funds went to every congressional district and most often to non-elite institutions, which seldom qualified for NSF research and fellowship grants. Institute funding was earmarked in the annual NSF funds appropriated by Congress. But despite this congressional support, the NSF institutes came under increased scrutiny in the seventies. Questions were raised about the efficacy of the concepts on which the institutes were modeled, with their emphasis on "top down" instruction by eminent scientists and their focus on subject matter expertise to the neglect of pedagogic technique and learning theory. There was little concern from staff about implementation of institute precepts in the school settings in which the teachers functioned, and little evidence that participation had affected teacher behavior and student learning and achievement. But there were other reasons as well, and they were probably more important than judgments about the program's effectiveness. The teacher institutes became linked to NSF's curriculum development initiatives, which became politically controversial. Furthermore, decreases in school enrollment and concerns about a coming surplus of scientists and engineers also contributed to the decision to phase out the NSF teacher institutes. By 1976, the program received almost no funding.

Changing concerns and priorities. Concerns about the quality of U.S. math and science education were temporarily eclipsed by desegregation and civil rights issues, which led to major restructuring of school systems and instructional materials. Teachers needed inservice or enhancement programs to learn to work more effectively with previously underserved students, including minorities and students with limited English proficiency. The focus shifted from secondary to elementary and middle school students. At the same time, because of the controversies and conflicts generated by the Vietnam War and a resurgence of progressive child-centered views, students and activists in urban areas demanded more relevance and individual choice (Bierlein, 1993). In response, graduation requirements were watered down or eliminated in some districts. Academic excellence took a back seat to equity issues, and specific math and science requirements were once more considered elitist and inappropriate for the large numbers of students who were unprepared to succeed in these fields. The shift in federal funding priorities contributed to the drastic reduction of NSF funding for precollege mathematics and science programs; NSF saw little reason to argue with these new priorities, although the elementary math and science curricula that had been developed earlier had proved quite successful with some of the targeted populations (Raizen, 1993).

The Call for Educational Reform in the 1980s: Excellence and Equity

Before long, the pendulum swung back again. The educational liberalism of the sixties and seventies was challenged by a growing number of critics who felt that education policymakers had neglected the issue of excellence, and who pointed to low achievement levels (as measured by the National Assessment of Educational Progress) and declines in national test scores as evidence of deterioration of the American educational system. Even more concern was generated by the results of international studies of mathematics and science achievement, particularly with respect to 13- and 14-year-olds, which showed American students with lower achievement scores than students in most of the other countries included in the comparisons (NSF, 1992; NCES, 1996). Given the growing concern about U.S. competitiveness in world markets, these data were especially disturbing. The renewed concern with educational quality and academic achievement triggered a spate of calls for reform by policymakers, scientists, educators, and special task forces.[2]

Simultaneously, various groups of educators and policymakers began to work on the development of new standards for mathematics and science teaching and learning.

Educational Reform in the 1990s and Implications for Professional Development

Superficially, the new call for reform might suggest a return to the academic priorities of an earlier period. However, this would be a misreading of what the proponents of the reform movement in

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[2]Probably most influential was *A Nation at Risk*, the 1983 Report by the National Commission on Excellence in Education. Other important documents were *Science and Mathematics in the Schools*, National Academy of Science, 1982; *Report of the Twentieth Century Fund Task Force on Federal Elementary and Secondary Education* (1983); and *National Education Goals*, adopted by the membership of the National Governors' Association in 1990.

academe, professional organizations, foundations, and federal, state, and local government bodies have crafted. Rather, reform combines the call for academic excellence with a commitment to equity; it also seeks to impart to all students knowledge and skills appropriate for successful participation as adults in a society increasingly driven by science and technology. All K-12 students regardless of gender and ethnic or linguistic background should acquire mathematical power and scientific literacy that will enable them to function successfully in today's world of rapid technological changes. To achieve this goal will require major changes in curriculum, instructional practices (many of them reminiscent of the tenets of progressive education), and testing or learning assessment practices. Given the decentralized character of the American educational system, the task is a formidable one. The simultaneous introduction of these changes in individual schools as well as in state and local administrative and supervisory bodies ("systemic change") is believed to be the key to the success of reform.

At present, science and mathematics education are the first targets of systemic reform, and specific goals and methods for these fields have been delineated. Systemic reform

- Involves all segments of a school system, from kindergarten through the 12th grade, with the elementary school years seen as especially important for the acquisition of mathematical power and scientific literacy by all students.
- Includes new standards that have been adopted for mathematics and science education.
- Requires ongoing professional development for teachers directed at leading students to think, reason, and make discoveries; promoting group work; and working with heterogeneous classrooms, rather than emphasizing lectures, textbooks, memorization of facts, or grouping of students by ability levels.[3]

Current Programs

The term "professional development" as used in the 1990s is similar to the term "school reform." Although apparently simple and

[3]See especially *Professional Standards for Teaching Mathematics*, published by the National Council of Teachers of Mathematics, Reston, VA, in March 1991, and *National Science Education Standards* (1996), National Research Council, Washington, DC.

easy to understand, it is a single label that covers a wide variety of services and experiences offered to teaching professionals. Today's professional development programs can be described in terms of two general dimensions: their focus and their structure.

Focus

"Focus" as used here means the content of the professional development program or the types of knowledge and skills that are being taught. The focus of today's programs varies along two dimensions: whether the purpose is to provide direct training or to build the capacity to provide training; and whether the skills and knowledge imparted primarily address pedagogy, content, or some combination of both.

Let us look first at the question of direct training versus capacity building. As shown by our brief review of the history of professional development programs, such programs traditionally have emphasized the direct training approach, modeling inservice strategies on the preservice model of knowledge enhancement. Thus, teachers have been brought together to learn about new pedagogies, new findings in their field, new tools for education, such as computers, or new policies in their district or state. The immediate goal of these programs is to have the participants hear about and integrate information on the topic covered into their own practice. Many argue, however, that this approach is not optimal, given the numbers of teachers who need to be reached. Instead, what is believed to be needed is building local capacity to provide ongoing training. Proponents of the capacity-building approach argue that the needs for support are so great that unless internal structures that can provide professional development are built or strengthened, the continuing needs of teachers cannot be met.

The second question regarding focus concerns what the learning is about. Is the focus of the professional development on how to teach, what to teach, or some combination of both? Programs stressing content see the role of professional development efforts as that of providing teachers with enhanced or advanced knowledge in their fields. This may include learning about new equipment that can be used in laboratories or other technological innovations that can support learning and promote students' interest. This information may be offered through classroom or workshop experiences or through research immersions in applied settings. Some of these efforts may be university based; others are placed in or closely linked with places where practicing scientists (or mathematicians or engineers) work. Many of these efforts, especially those in applied settings, also provide experience in "doing science" as part of a scientific research team.

Experiences that focus on pedagogy stress the need to reform the teaching/learning interactions, with the present emphasis on the constructivist approach Such programs typically are designed to provide teachers with skills to use hands-on, inquiry-based instruction, to connect the students' learning experiences to real-world tasks and careers, and to be a coach or facilitator rather than a lecturer. Depth is stressed over breadth, problem solving over memorizing facts.

Over the last decade there has been a pendulum swing between the content and pedagogical focus. Today, the need for improvements in both arenas is recognized, with international comparative studies such as the Third International Mathematics and Science Survey (TIMSS) showing teachers in the United States to be needing support in both areas (NCES, 1996).

Structure

"Structure" as used here means the approach to planning and delivering teacher enhancement programs. There are two schools of thought that coexist today with regard to the structure of teacher enhancement programs: although an oversimplification, the contrast between them is the extent to which the experiences are expert-driven or teacher-driven. (This contrast shares many characteristics with the top-down, bottom-up debate that continues to rage with regard to school reform.) At the extreme, the expert-driven model involves experiences that are directed by experts (in mathematics and science, these experts are frequently practicing scientists in academic or applied settings) who share their knowledge, work environment, and work experiences with teachers who come to learn with and from them. Lieberman (1995) characterizes this method as the conventional approach, which defines staff development as "a transferable package of knowledge to be distributed to teachers in bite-sized pieces" (p. 592).

At the other extreme are teacher-driven experiences, which aim as much at changing culture as gaining new skills and knowledge. These tend to be of relatively long duration and to embed the development activities in the teachers' place of work, the school setting itself. Proponents of the teacher-driven approach see schools as learning organizations and believe real change requires collective problem solving, practice, and creating a culture of inquiry (Lieberman, 1995).

In addition to philosophy, characteristics that distinguish these two approaches, and may even vary within them, include intensity, target population, and geographic scope.

Intensity. Professional development activities range from short, single-shot experiences to multi-year programs. Some teacher enhancement programs are short-term workshops or inservice days in which a particular technique is explained or a new policy introduced. Others are longer term summer workshops or mentorships that are several weeks in duration and may include year-round followup activities. Still others are based on a multi-year format, with teachers graduating through stages. These may include alternating cycles of learning and application across a 2- to 3-year period. While there appears to be general agreement that the ongoing, more intensive type of professional training is preferable, extended professional development is not always the model used.

Target population. Programs vary in the extent to which they target individual participants versus teams of participants from a single school or a site. In the latter case, the teams may include several teachers from the school, may be more heterogeneous and involve teaching, administrative, and even community personnel, or may serve multiple individuals from the same site over consecutive training sessions. It has been argued (Lieberman, 1995) that the school-based approach has many advantages—a critical mass of trained personnel, a more supportive environment for change, a set of services that are more closely aligned with the needs of the school. Others feel that even changing one teacher can make a difference, and that bringing together teachers from different schools and environments can be both energizing and renewing.

Geographic scope. Programs vary in whether they are targeted at the local, regional, or national level. While teacher-directed programs are almost always local, those based on the expert model or those that involve research experiences can be local, regional, or national in scope. It should be noted that one advantage of the more local model is that the potential for followup and continued support during the time following training is much greater. While some accommodations can be made for geographic disbursement, such as newsletters or Listservs, the potential for continued interaction and support is simply much greater where the participants come from areas that are close to one another.

Current Goals of Professional Development Programs

Programs also vary in terms of their goals—especially the extent to which the teacher rather than the student is the primary target of program impact. While in general terms all programs acknowledge that the goal of professional development is to provide improved instruction that will contribute to improved student achievement, many have traditionally considered student achievement to be too distal or affected by too many different factors. Changing or assisting teachers is seen as an end that is important, and sufficient, in and of itself. Potential goals follow:

Increasing teacher knowledge. A primary goal in professional development continues to be increasing teacher knowledge. One reason for the need to increase teacher knowledge is that mathematics and science teachers, especially those who teach elementary students, often receive inadequate preparation in these subjects in their undergraduate education. Because of inadequate preparation, many teachers do not feel confident about their teaching abilities in mathematics and science and often do not enjoy teaching these subjects. Thus, many programs seek to increase teachers' confidence by giving them the opportunity to understand more about math or science and more about methods for teaching the subjects.

Another reason for increasing teacher knowledge is that teachers today are expected to be knowledgeable and capable in areas that they may not have dealt with as undergraduates, such as computers, environmental issues, and new technologies. Teachers today also need help in assuming roles that are nontraditional for them, such as developing assessment capabilities and becoming leaders in their schools. Given changes in technology, curriculum, and teaching methods, many argue that it is not feasible to completely prepare a preservice teacher for a lifetime of teaching (e.g., Meserve, 1989).

Providing teacher renewal and the opportunity for networking. Another important aspect of the current reform movement is renewal and the opportunity for continued networking. Although many professional development programs do not cite networking as a goal, many stress renewal and have networking components. Networking with others is often used to decrease teacher isolation and increase professionalism by increased opportunities for teachers to interact with one another and other professionals to share their experiences and knowledge. A great deal of networking takes place through contacts with others in the teacher enhancement programs and through professional development activities, such as attending conferences. Some programs also support and encourage teachers to network through computers. E-mail computer networking is one of the major followup activities used by professional development summer institutes that serve participants from across the nation. Through these contacts, teachers have the opportunity to learn about new developments in their field, to keep up with other program participants and mentors, and to share their experiences.

Increasing leadership and empowerment. Many programs emphasize the development of teacher leaders. Teacher leaders are very useful in reaching out to and teaching other teachers. Programs that develop teacher leaders can indirectly reach many more teachers when teacher leaders share their knowledge with others.

Professional development programs also may serve to empower teachers. In addition to increasing teacher empowerment through leadership development, many current programs emphasize teacher empowerment through their methods of teaching teachers. An assumption in many of the new programs is that teachers should have direction and control over their own learning and professional development (Shavelson, Copeland, Baxter, Decker, & Ruiz-Primo, 1994). Instead of top-down programs in which teachers passively receive knowledge, the emphasis today is on the active participation of teachers in their own learning. When teachers have more ownership of their education, they are expected to be more invested in the changes brought about by it.

Changing classroom practice. Changing classroom instruction is another major goal of professional development programs. Most programs help teachers in some way to apply what they learned in the program to the classroom, for example, by giving teachers materials or equipment for classroom activities or having teachers write detailed plans for how they intend to use what they learned in their classroom. Some programs focus on this aspect more directly and give teachers the opportunity to field test what they have learned with students in the program or give teachers coaching or feedback in the use of new instructional tools or materials in their home classrooms.

Increasing student interest and achievement. An underlying goal of professional development programs is to increase students' interest in mathematics or science and to improve achievement. In some programs, this is often not an explicitly stated goal; however, through improved curricula and improved teacher knowledge and teaching methods, it is expected that students will benefit from these improvements. Programs aim both at providing instruction that will help students become more "world class" performers and at creating a more scientifically literate society.

Enhancing minority participation. An even more indirect goal of programs is to increase participation of minorities in science and mathematics. Some professional development programs are designed to attract more students who are members of groups that do not usually pursue careers in science or mathematics, such as minorities, females, and persons with physical disabilities. Some programs have required that teachers who are part of minority groups be involved, while others have developed models for inservice that are particularly encouraging to the development of leaders among underrepresented groups. The idea behind some of these efforts is that teacher leaders from underrepresented groups will encourage students from these same groups to become more interested in mathematics and science.

Evaluation Findings

It is clear that professional development programs are popular and valued widely, but what do we really know about their impacts? A report by the General Accounting Office (GAO) asserts that the answer is really very little. The 1994 GAO report on the Department of Energy's Precollege Math and Science Education efforts was highly critical, chastising the Department for both its failure to conduct sound evaluations and the lack of data linking participation in professional development programs to one specific outcome, student achievement (GAO, 1994). GAO supported its 1994 conclusions about the lack of efficacy of professional development programs by citing studies previously reviewed in its own 1984 report (GAO, 1984). While there are some flaws that can be cited with regard to this report (for example, the contention that there is stronger evidence on the efficacy of curriculum and systemic change efforts than there is on professional development, and their sole reliance on student outcomes as a measure of program success), the GAO report does sound an alarm, identifying a lack of comprehensive and methodologically sound evaluations.

While this paucity of evaluation literature is disappointing, it is not surprising given the limited resources that have been devoted to evaluation of federal mathematics and science programs in general. As noted in the report of the Expert Panel for the Review of Federal Education Programs in Science, Mathematics, Engineering, and Technology (SMET), "the impact of current Federal efforts in SMET education remains unclear....Federal expenditures are being made with too little overall planning and with inadequate evaluation." In fact, for a majority of federally funded SMET education programs, no evaluation information is available at all (Committee on Education and Human Resources, 1993). Furthermore, only recently has there been a clear mandate from the federal government that all federal agencies evaluate their SMET education programs and that these evaluations be "results-oriented." Snyder and Frechtling (1997) writing about the changing demands for evaluation of professional development programs summed up the change as follows:

> *Recently the demand for evaluation data has increased, changing in both focus and form. Instead of solely targeting questions related to perceptions and descriptions of program characteristics, evaluators are being asked to address questions related to outcomes for schools, classrooms, and students. Instead of relying primarily on self-reports of program outcomes, evaluators are being asked to incorporate methodologies that provide harder data, preferably data from multiple data sources.* (p. 34)

In this section, we present a review of evaluations of teacher enhancement programs using both published and unpublished materials. Our review generally corroborates the GAO's conclusions. Further, they show that few evaluations have even addressed the question of the linkage between participation in a teacher enhancement experience and student outcomes. Typically, these evaluations have looked at the following outcomes:

- Were the participants satisfied with the training experience?
- Did the participants acquire new knowledge and teaching skills?
- Were the new skills transferred to classroom practice?
- Did the experience have a positive impact on teachers' feelings of professional renewal and career satisfaction?
- Do teachers feel more empowered and able to take on leadership roles in their home schools and to act as disseminators of information?
- Have students' attitudes toward math and science and their achievement in these areas improved as a result of teachers' participation in programs?

As might be predicted, the majority of studies have looked at the first two outcomes, with fewer addressing the impacts further down the list. To illustrate the status of the evaluation literature, selected studies and their outcomes are presented.

Participant Satisfaction

A high degree of participant satisfaction is one of the most prevalent findings concerning teacher enhancement programs. Many programs report that through either exit or followup surveys, participants have indicated that the program was a satisfying and positive experience for them.

In general, evaluation studies report these findings in two ways. First, they report respondents' answers to Likert-like scales in which they are asked to rate the degree to which they were satisfied with the program. For example, in the Department of Energy's followup survey to the Teacher Research Associates (TRAC) program (Vivio & Stevenson, 1992), participants were asked in the exit survey to rate their overall satisfaction with the program. On a scale from 1 (very dissatisfied) to 10 (very satisfied), more than 70 percent responded with a 9 or 10, with an average rating of 9. In the evaluation of the Great Starts Mathematics Approach (Jarvis & Blank, 1989), 90 percent of the participants said that the program had a major impact in influencing their understanding of ways to teach math.

Program evaluations also report comments made by program participants to illustrate the kinds of reactions received to workshops. Participants in the Eisenhower-funded program Implementing the

National Council for Teachers of Mathematics Standards for School Mathematics for the 21st Century (Kroll, 1990) said that the workshops "excited and inspired" them. The report on DOE's TRAC program (Vivio & Stevenson, 1992) included quotes from participants such as the following: "It was very refreshing." "It gave us a sense of self-worth." "My thoughts are valuable to someone." "Someone is going to listen to me." These are typical responses of teachers about their teacher enhancement experiences.

Teachers in general appear to feel very positively about their experiences in teacher enhancement programs. While these reactions are often reported as overall satisfaction, participants frequently are asked to rate their satisfaction with specific aspects of the programs. These outcomes are discussed more fully in the sections that follow.

New Skills and Teacher Techniques

Most studies provide evidence that teachers feel they have gained knowledge or increased their skills through teacher enhancement programs. There are fewer studies, however, that provide evidence of increased teacher knowledge using measures other than self-report.

With few exceptions, participants in teacher enhancement programs rated themselves as having increased their knowledge of science and mathematics, and of ways to teach the subjects, as a result of their experiences. For the most part, these data on teacher ratings, collected at the conclusion of the teacher enhancement program, provide short-term assessments. For example, Taagepera, Miller, and Benesi (1985) reported that 88 percent of the 100 teachers in the University of California-Irvine (UCI) Summer Science Institute agreed that courses were increasing their understanding of basic concepts in science. No evidence beyond that of self-report was provided.

A few studies have included standardized measures of gains in teacher knowledge. Some of these studies, however, are plagued by measurement difficulties. For example, Horak, Blecha, and Enz (1982) found no increase in teacher science knowledge, but they used such an easy test that many teachers scored 100 percent on both the pre- and post-program tests. When measures are adequate, however, standardized tests can show significant increases in teacher knowledge. In one report, Weiss, Boyd, and Hessling (1990) cite a study in which participants improved from a median score at the 62nd percentile on the National Science Teachers Association/American Association of Physics Teachers (NSTA/AAPT) high school physics test to a median score at the 85th percentile during the second summer, to a median at the 99th percentile by the third summer. In another study (Rhoton, Field, & Prather, 1992), there were statistically significant gains in teachers' instructional and curricular skills and content mastery as measured by pre- and post-program tests.

In summary, most evaluations report that teachers feel better about their content knowledge and teaching skills as a result of teacher enhancement programs. Increased confidence about their subject matter knowledge can lead to a decrease in anxiety about teaching math and science. Although most of the evaluations are based on teachers' self-report, increased teacher confidence about knowledge and skills has been considered an important contributor to adaptive and effective teacher behaviors in the classroom.

Transfer of Skills to Classroom Practice

Teachers report a number of different ways in which they have applied their lessons to practice. However, there has been limited corroboration of the actual implementation of changes by evaluators.

Marable (1990) reported that teachers indicated that they developed curriculum materials for use in their classrooms. Boser and associates (1988) found that teachers reported a significant increase in time devoted to lab activities in classes as a result of the Science Teachers Research Involvement for Vital Education (STRIVE) program. Finally, Hadfield (1992) found in post-inservice questionnaires administered after teachers had returned to their home schools that teachers reported spending more time teaching math, using materials from the workshop, and getting positive responses from students about instruction.

One study (Eash, Hagar, & Weigrecht, 1989) did attempt to assess classroom changes using measures other than self-report. The researchers used students as observers of teachers to support their self-reports of changes. Specifically, they found that student reports verified participant teachers' claims of changes in classroom approach in the following activities: requiring students to plan and organize cooperative group projects; including in classroom work applications of science concepts in industry; stressing the importance of science in society; increasing student interest in science as a career; increasing the use of questioning during class; and introducing new materials into the regular curriculum. In another study (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989), classroom observations were included in the evaluation. These observations indicated that even though specific instruction patterns were not prescribed in the teacher enhancement workshop, the teachers who participated in the training activities spent more time in the classroom talking about problems and discussing alternative solutions than did teachers of control classes.

Two recent efforts have begun to provide more robust evidence in this area. The first is a formative study being conducted by Iris Weiss and Horizon Research, Inc. With funding from NSF, Weiss, Montgomery, Ridgway, and Bond (1998) are documenting the implementation of what are called local systemic change (LSC) projects. The goal of the LSC program is to improve the teaching of science, mathematics, and technology by focusing on the professional development of teachers within whole schools or school districts. Each targeted teacher in a K-8 project is to participate in a minimum of 100 hours of professional development; for projects targeting teaching in grades 6-12, the minimum is 130 hours over the course of the project. In addition to its focus on involving all teachers in a jurisdiction, the LSC initiative is distinguished from previous professional development efforts by its emphasis on preparing teachers to implement designated exemplary mathematics and science instructional materials in their classrooms (Weiss et al., 1998). This study addressed the following issues:

- What is the overall quality of the LSC professional development activities?
- What is the extent of school and teacher involvement in LSC activities?
- What is the impact of the LSC professional development on teacher preparedness, attitudes, and beliefs about mathematics and science teaching and learning?
- What is the impact of the LSC professional development on classroom practices in mathematics and science?
- To what extent are school and district contexts becoming more supportive of the LSC vision for exemplary mathematics and science education?
- What is the extent of institutionalization of high-quality professional development systems in the LSC districts?

This study provides one of the most comprehensive examinations of the implementation of such programs conducted to date.

A second study, the Multi-Agency Study of Teacher Enhancement Programs (Frechtling, 1997), documented the classroom impact of professional development programs funded by five federal agencies. Programs included in this study were believed to represent "best practices" in professional development by the agencies supporting them. The study included projects that attempted to enhance teachers' knowledge and skills through both direct modeling and immersion in the research experience. The study combined several data collection techniques: site visitations to the professional development programs themselves, teacher interviews, teacher surveys, and site visits with a small sample of program participations to observe instruction and interview colleagues. The study found that both types of professional development programs appeared to change teachers' classroom practice.[4] Reported changes were greater at the elementary than the senior high school level. Both teachers who initially reported using standards-based practices and those that did not appeared to gain from their experiences. One important finding from this study was that the context of the school or district is very important. Teachers who worked in more reform-oriented environments showed higher levels of implementation of practices aligned with standards-based instruction than those who came from less supportive environments.

Impact on Renewal and Career Satisfaction

Many advocates of teacher inservice mention that teachers see a sense of renewal and increased connection to their field and profession as an important benefit of these programs. Teachers place strong value on the opportunity to share ideas and teaching techniques that these programs provide.

Jarvis and Blank (1989) report that the comment most often made about the program concerned the personal and professional benefits obtained from exchanging and sharing ideas with one another. Taagepera, Miller, and Benesi (1985) indicated that teacher contact with professors in the program was a critical component of the institute's success. This contact resulted in future collaborative efforts, such as a Saturdays for Science program and the NSF-sponsored UCI Science and Math Mentor Teacher Program. Lombard, Konicek, and Schultz (1985) reported that all participants in the Science

[4]The sample of professional development programs that used primarily a research approach was too small to draw firm conclusions about their relative effectiveness.

Teaching and Development of Reasoning workshops indicated that one important value of the workshops was the opportunity to meet together and discuss their experiences and ideas. One program, The Urban Mathematics Collaborative (Heck, Webb, & Martin, 1994), was based on the assumption that teacher networking is an inherent part of the collaborative effort because it "reduces teachers' sense of isolation, encourages professional enthusiasm and innovation in teaching, and exposes teachers to new developments and trends in mathematics and instruction." Finally, Armstrong (1987) reported that participants believed that the best aspect of the Leadership Institute was the opportunity for sharing ideas with colleagues.

Teachers frequently report that professional development experiences influenced their feelings of confidence about teaching math and science and their sense of satisfaction about their career choice. Weir (1988) reported that participants in a month-long summer science institute felt more confident about teaching science to children, and that they subsequently made more time for science in their teaching, "no matter what." Other programs, such as NSF-sponsored programs that took place on college campuses during the summer as well as during the school year (Orton. 1980), have reported that an outcome of the program was an increase in participants' going on for master's degrees, a sign of renewed motivation and a desire for advancement. Teachers also demonstrate a sense of renewal through taking on new leadership roles as teachers, thereby advancing their careers into positions such as mentor teachers and curriculum specialists.

Impact on Leadership and Dissemination

Another bright spot in professional development programs has been their effect on teacher leadership and empowerment. In fact, one fundamental goal of these projects has been to develop cadres of teachers who will take the lead in promoting changes in math and science education.

In the San Francisco Math Leadership Project (Armstrong, 1987), there was a dramatic increase in teachers' participation in professional associations, and participants saw themselves as emerging as math leaders in their schools. Kroll (1990) reported that workshop participants shared a great deal about their experiences with other teachers in their home schools who had not attended the workshop. Leadership was also evidenced at faculty meetings, with participants acting as recruiters, trainers, and support personnel for the project in the future. Henderson and Brown (1987) reported that the Monterey Bay Area Mathematics Project resulted in an increase in participation in professional development activities. Project participants also conducted inservice sessions for other teachers. Finally, Garner-Gilchrist (1993) stated that Mathematics Institute Program participants conducted workshops in their respective schools following the institute.

The evidence of teacher leadership and empowerment illustrates how professional development programs can create a ripple effect that reaches beyond the influence on actual participants. Participants themselves became proponents of positive change. However, this ripple effect too often fails to occur and evidence suggests that explicit training or support may be needed (Frechtling, 1997).

Student Outcomes

In general, evaluations of teacher enhancement programs have rarely produced credible evidence of positive student outcomes, particularly in the area of student achievement. This is because most evaluations have surveyed teachers who can only report their impressions of changes in students' achievement or attitudes. Further, the adequacy of existing measures of achievement in mathematics and science have been strongly questioned, and more acceptable ones are only in the early developmental stages. Nevertheless, a small number of studies have addressed the impact of teacher enhancement programs on students.

One study in particular stands out. Using pre- and post-program test measures of student achievement, Rhoton, Field, and Prather (1992) found statistically significant gains in the performance of students whose teachers had participated in an NSF Science Education Leadership Institute. It should be noted that this project was a long-term intervention and included the participation of the school principal, and the two factors made this professional development program fit into a larger systemic reform effort. Eash, et al., (1989) also used pre- and post-test measures administered to students in classes taught by teachers who had participated in an NSF teacher enhancement workshop. Results indicated that these students demonstrated improved attitudes toward science education and greater academic achievement when compared to students taught by teachers who had not participated in the workshop.

Another evaluation (Madsen & Lanier, 1992) used tests, written work, and verbal comments to measure student outcomes after teachers had participated in an intensive staff development program. The Support Teacher Program included updating teachers' knowledge about current research on teaching and learning mathematics and working with other professionals in a peer support program. At the end of one year, student results indicated a more positive attitude towards mathematics, an improved ability to solve problems, and an increased conceptual understanding of mathematics. Finally, Carpenter et al. (1989) reported that students in classes where teachers had received training in "cognitively-guided instruction" performed better on complex addition and subtraction and problem-solving activities than students in control group classes.

However, a multi-year study by Stallings and Krasavage (1987) raises some questions about whether or not such changes may be highly transitory. Stallings and Krasavage reported that professional development based on the Madeline Hunter model led to changes in teacher practices, student engagement, and achievement during the first two years of an intensively supported follow-through program. In the third year, when assistance to teachers was removed, both instructional fidelity and student performance declined.

Other than these studies, most evaluations either ignore student achievement or provide unconvincing and often anecdotal teacher reports of positive student outcomes, relying instead on self-report. A large-scale evaluation of NSF Teacher Enhancement programs (Abt Associates, 1993) also found that teachers report significant gains in students' enthusiasm and achievement in science. However, because these findings are based on self-report, they provide unconvincing evidence of real gains in student performance.

Two studies currently in their initial stages are attempting to take a closer look at impacts on student outcomes. In its beginning stages is a study of Summer Work Experience Programs for Teachers (SWEPTs) on student achievement, teachers classroom practices, and teacher leadership.[5] SWEPTs provide research experiences for teachers in both industry and research settings. The experiences may cover one or more summers, with some kind of contact and support frequently continuing throughout the school year. This study will examine the

[5]This study is supported by the National Science Foundation. It is being directed by Dr. Sam Silverstein at Columbia University.

effects of eight different programs located across the United States using a target population of high school teachers and their students. The same teachers will be followed over two years time, and their behaviors and their students' learning will be compared to that of a control group.

The second study is a multifaceted study of the Eisenhower Professional Development Program. The evaluation, supported by the Department of Education, is designed to provide both indepth description of the services provided through these funds and an examination of what has been learned about their impacts on student learning. Initial findings from this study are found in Birman, Reeve, and Sattler (1998).

Conclusion

Taken together, what do these evaluations tell us about the impact of professional development programs? The picture is clearly mixed, with evidence that can both give comfort to supporters and fuel the concern of critics. Despite the reliance on self-report, these evaluation findings provide substantial support for the benefits of professional development programs, at least where goals such as new knowledge, renewal, and professional leadership are concerned. The number of studies that report positive impacts in these areas suggests that participation in teacher enhancement programs makes teachers feel better about themselves, their profession, and their ability to be effective in their roles. Results with regard to classroom practice are less solid, but appear to be in the right direction. Teachers report using what they have learned, both in terms of content and process.

Support for the impact of professional development programs on student outcomes is, however, less convincing, given the evidence that we have been able to locate. Most studies either do not address student outcomes or provide indirect evidence that cannot be rigorously evaluated.[6] This lack of evidence should not be considered surprising, given the difficulty of establishing such linkages and the relatively insignificant amount of funding that has been allocated to most evaluation efforts. The situation is similar with regard to teacher leadership and dissemination of what is learned through professional development. What is needed is a well-designed, longitudinal effort

[6]It should be pointed out, however, that changing student outcomes has not always been the goal of professional development programs. Often, they have been designed to change teacher behaviors.

that can document changes (or lack of changes) in teacher skills, teacher classroom behaviors, teacher leadership, and student attitudes and achievement over time. Such a study must look not only at the contribution of the professional development experience, but also at how the learning environment—the school and the classroom—is structured to support and reinforce the changes that need to take place. It is unlikely, however, that even the best designed study will show that the teacher enhancement and *nothing else* has caused any changes that might be found. Educators today see professional development as a major component of reform efforts, not as a stand-alone treatment. Studies should be designed to reflect the logic of this model and examine how professional development contributes to the success of the overall effort.

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