DOCUMENT RESUME

ED 442 674 SE 063 816

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TITLE What Happens to First Year Teachers Prepared To Make Connections between Science and Mathematics When They Enter the Workplace?

SPONS AGENCY National Science Foundation, Arlington, VA.

PUB DATE 2000-00-00

NOTE 19p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (New Orleans, LA, April 28-May 1, 2000).

CONTRACT DUE9255745; DUE9814650

PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *Beginning Teachers; Case Studies; Cultural Influences; Educational Change; Elementary Education; *Interdisciplinary Approach; *Mathematics Instruction; *Mathematics Teachers; Middle Schools; *Science Instruction; *Science Teachers; Surveys

ABSTRACT

This study's purpose was to present a detailed description and an interpretation of what happens to first year new teachers who are prepared to make connections between science and mathematics and to teach in a manner consistent with the recommendations in the national science education reform movement. The focus was on two sets of participants: (1) all new graduates (N=57) from the Maryland Collaborative for Teacher Preparation [MCTP], a statewide reform-based undergraduate teacher preparation program supported by National Science Foundation funding, and (2) a select sample of first year new graduates of the program in the workplace (elementary and middle level schools) (N=5). Survey and case study methodologies were used. Survey results were reported in comparison to a national sample. Also reported were differing social strategies enacted by the five new teacher case study participants in response to perceived constraints in the workplace. Research suggests that a reform-oriented mathematics and science teacher preparation program can recruit, educate, and graduate a cadre of new teachers who are employed by school districts. The new teachers from such a teacher preparation program have the capabilities and intentions to teach mathematics and science in a reform-based manner that makes connections between the disciplines by using high quality science mathematics. However, the new teachers' school cultures were a major factor in whether reform-aligned mathematics and science teaching was implemented regularly by the new teachers and if the new teachers continued to teach in those schools. (Contains 17 references.) (Author/ASK)

What Happens to First Year Teachers Prepared to Make Connections Between Science and Mathematics When They Enter the Workplace?

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A paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans, Louisiana, April 28-May 1, 2000.

Abstract

This study's purpose was to present a detailed description and an interpretation of what happens to first year new teachers who are prepared to make connections between science and mathematics and to teach in a manner consistent with the recommendations in the national science education reform movement. The focus was on two sets of participants: 1) all new graduates (N=57) from the Maryland Collaborative for Teacher Preparation [MCTP], a statewide reform-based undergraduate teacher preparation program supported by National Science Foundation funding, and 2) a select sample of first year new graduates of the program in the workplace (elementary and middle level schools) (N=5). Survey and case study methodologies were used. We reported survey results in comparison to a national sample. We reported differing social strategies enacted by the five new teacher case study participants in response to perceived constraints in the workplace. Our research suggests that a reform-oriented mathematics and science teacher preparation program can recruit, educate, and graduate a cadre of new teachers who are employed by school districts. The new teachers from such a teacher preparation program have the capabilities and intentions to teach mathematics and science in a reform-based manner that makes connections between the disciplines by using high quality science mathematics. However, the new teachers' school cultures was a major factor in whether reform-aligned mathematics and science teaching was implemented regularly by the new teachers and if the new teachers continued to teach in those schools.

What Happens to First Year Teachers Prepared to Make Connections Between Science and Mathematics When They Enter the Workplace?

There is currently considerable interest in preparing science teachers to make connections with mathematics (see, for example, National Resource Council, 1996). However, there is a dearth of empirical studies that systematically study the implementation of this teaching innovation over extended time (i.e., the entire undergraduate experience and the first few years of full time teaching practice). This paper presents a detailed description and an interpretation of what happens to first year new teachers who are prepared to make connections between science and mathematics and to teach in a manner consistent with the recommendations in the national science education reform movement. The focus in this study is on two sets of participants: Set 1, all (N=57) new graduates from a statewide reform-based undergraduate teacher preparation program supported by National Science Foundation funding, and Set 2, a select sample (n=5) of first year new graduates of the program in the workplace (elementary and middle level schools). This study is one of a series of studies in a longitudinal research program investigating the Maryland Collaborative for Teacher Preparation [MCTP] that have been reported at NARST (last 5 years), AERA (last 5 years), and AETS (twice), and NSTA (once).

This study is conducted within a macro-research agenda within the mathematics and science education research communities that are focusing on the possible links between features of teacher preparation programs and the performances of new teachers (Simmons, et al., 1994). Currently, little is known in this context of reform about how newly graduated specialist teachers of mathematics and science from innovative teacher preparation programs are inducted into cultures of extant practice (Coble & Koballa, 1996). Pekarek, Krockover and Shephardson (1996) asserted that research-based insights of most value will come from studying teacher preparation programs that are seeking to implement recommended innovations in teacher preparation.

Context of the Study

The MCTP is a National Science Foundation (NSF) funded statewide undergraduate program for students who plan to become specialist mathematics and science upper elementary or middle level teachers. While teacher candidates selected to participate in the MCTP program in many ways are representative of typical teacher candidates in elementary teacher preparation programs, they are distinctive by agreeing to participate in a program that consists of an extensive array of mathematics and science experiences (formal and informal) that make connections between the two disciplines.

The goal of the MCTP is to promote the development of professional teachers who are confident teaching mathematics and science using technology, who can make connections between and among the disciplines, and who can provide an exciting and challenging learning environment for students of diverse backgrounds (University of Maryland System, 1993). This goal is in accord with the educational practice reforms advocated by the major professional mathematics and science education communities:

The MCTP is designed around these salient reform-based recommendations:

- new content and pedagogy courses that model inquiry-based, interdisciplinary approaches combined with regular opportunities for teacher candidate reflection;
- the participation of faculty in mathematics, science, and methods committed to modeling best teaching practices (especially by diminishing lecture and emphasizing problem-solving);
- the development of field experiences in community schools with exemplary teachers trained to serve as mentors;
- the availability of summer internships in contexts rich in mathematics and science;

• and, the support of new teachers by university and school personnel during their first years of teaching.

Theoretical Assumption and Research Methodological Approaches

A fundamental assumption of the MCTP is that changes in pre-secondary level mathematics and science educational practices in the workplace require reform within the undergraduate mathematics and science subject matter and education classes teacher candidates take throughout their teacher preparation programs (NSF, 1993). To test this assumption, two associated studies were designed: (1) A comparison study (survey) was designed to investigate all new MCTP teachers' beliefs about mathematics and science and their actions toward the teaching of those subjects; and (2) An empirical study using a case study approach (N=5) was designed to investigate curricular connections made by a select sample of MCTP new teachers throughout their first year of teaching experience. The case study took a symbolic interaction theoretical stance (Blumer, 1969; Denzin, 1978). Symbolic interactionism makes the assumption that meanings are constructed by humans through interaction. A central premise is that inquiry must be grounded in the empirical environment under study. In addition, a cultural perspective was used (McGinnis & Simmons, 1999) to interpret the participants' enculturation into extant workplace cultures. The hypothesized stages of induction as proposed by Ryan (1986) and Spector (1989) assisted in framing the cultural perspective.

In this study, we focus on answering these highly significant research questions:

How do new specialist teachers of mathematics and science who graduate from an inquiry-based, standards-guided innovative undergraduate teacher preparation:

(1) view their subject disciplines;

(2) enact their roles as teachers; and,

(3) think about what they do when teaching science and mathematics with upper elementary/middle level students?

Answers to these questions, supported by a thick description of a select samples' work lives, contribute to a better understanding of how new reform-based teachers are enculturated into the extant mathematics and science teaching cultures of the elementary/middle school workplace.

Part One: Survey Measurement of What the New MCTP Teachers Took to the Workplace (Actions and Beliefs About the Nature and Teaching of Mathematics and Science)

In this section of our report, we describe the use of a survey instrument to measure the new MCTP teachers' actions and beliefs about the nature and teaching of mathematics and science. The focus of the analysis of the survey data is a comparison of responses between our MCTP new teachers in 1999 and the National Science Foundation's national teachers' sample conducted in 1994-1995 (National Science Foundation, 1998).

Methodology

The method used to collect this data was a mailed survey to all new MCTP teachers (N=57). We desired to document the total population of MCTP new teachers' reported beliefs about mathematics and science and their actions toward the teaching of those subjects so we could compare them with a national sample of teachers. This required us to develop a new survey consisting of items reported in the National Science Board's 1998 Science & Engineering Indicators (NSB-98-1). We named this new 51-item survey *MCTP New Teachers' Actions and Beliefs of Mathematics and Science*. This survey was

sent out by mail to our entire sample of MCTP graduates in the spring 1999. See Appendix A for a copy of the instrument.

The analysis used data from all completed surveys (n=33; nearly a 60% response rate). The surveyed included 5 sections of items. Section one asked, "To what extent do you agree or disagree with the following statements?," followed by 18 questions divided between mathematics and science. Section 2 asked, "To be good at mathematics/science at school, how important do you think it is for students to...(fill in the blank with each of the 12 items below). Section three consisted of three questions asking, "What is your familiarity with the [standards] documents listed below?" Section four offered fourteen questions for the teachers under the heading, "Please indicate if you use (or would use, if you taught mathematics and science) the instructional strategies listed below." Sections 5 included demographics from the teachers involved in the study.

Findings

Tables 1, 2 and 3 summarize select response data from the spring 1999 survey along with data reported in the 1994-1995 national NSF sample of elementary and middle level teachers (Note: We report our data similarly to the NSF data, i.e., by presenting combined "strongly agree" and "agree" responses.)

Beliefs. Several attitude and belief questions showed very close agreement between the MCTP teachers and the NSF teachers in both science and mathematics. For example, regarding whether mathematics is a formal way of representing the real world, the responses of MCTP teachers (71%) fell rather close to those of NSF teachers (79%). However, for the same question in science, there was a significant difference between MCTP teachers (58.1%) and the NSF teachers (84%) (Table 1).

When asked if mathematics is primarily a practical and structured guide for addressing real situations, 75.8% of the MCTP teachers agreed, as compared to 90% of the NSF surveyed elementary and middle level teachers. When asked the same question in science, however, 69.7% of the MCTP teachers agreed as compared to 90% of the NSF teachers. When asked whether more than one representation in mathematics should be used in teaching, the majority of both the MCTP teachers (87.9%) as well as NSF teachers (98%) agreed (Table 1).

When asked to rank the importance of mathematics/science to several items, the category of teachers' perceptions of student skills required for success in mathematics and science produced very similar results among the NSF teachers in 1994-1995 and the study administered with the MCTP teachers in 1999 (Table 2.)

An interesting difference in opinions occurred when the teachers were asked if some students have a natural talent for mathematics while others do not: 71.9% of the MCTP teachers agreed, as compared to 82% of the NSF teachers. However, when applying the same question to science, 53.1% of the MCTP teachers agreed as compared to 62% of NSF teachers (Table 1).

One question that showed a large difference was the importance of thinking in a sequential manner. In mathematics, 54.5% of the MCTP teachers as compared to 80% of the NSF teachers found it very important, and in science, 48.5% of the MCTP teachers as compared to 80% of the NSF surveyed teachers.

Actions. Our survey detected differences in instructional strategies for all surveyed items. The new MCTP teachers were in their mathematics and science instructional strategies more likely than the comparison group of elementary and middle level teachers to: Assist all students to achieve high standards; provide examples of high standard work; use authentic assessments; use standards aligned curricula (and textbooks and materials); and make connections with science. In addition, in science instruction the new MCTP teachers were also more likely to use telecommunication-supported

instruction. In most instances, the percent difference between the new MCTP teachers and the comparison group was substantial (e.g., Mathematics, make connections with science, 87.9% to 27%; Science, 87.9% to 29%). See table 3.

Conclusion

While the survey results were tentative (i.e., they were self-reports and measured only the new MCTP teachers' beliefs and actions who were graduates as of fall 1998), they suggested that the new MCTP teachers were in alignment with the goals of the MCTP program in vital ways. In particular, the manner in which they enacted instructional practices (or would if they were teaching mathematics and science) was noteworthy and suggestive that graduates of the MCTP program were reform-based teachers.

Part Two: A Case Study of Five MCTP New Teachers in the Workplace

While an earlier report (see, McGinnis, Parker, & Graeber, 2000) examined in great detail the enculturation over two years of our five case study new MCTP teachers, what follows is a summary. Interested readers of this portion of this paper are pointed to that earlier report to hear in particular the new teachers', their students', and their principals' voices.

Research Strategies

Methodology. Since this study involved an in-depth examination of phenomena, we used the qualitative case study strategy. This case study traces the teaching/learning experiences of the participants throughout their first years of teaching. As recommended by Page (1991) and McGinnis & Simmons (1999) the analysis of the data was particularly sensitive to the participants' perspective of each of the school's culture or meaning system.

Data Collection and Analysis. Data sources include individual and focus group participant interviews (recorded and transcribed), analysis of classroom teaching practices (videotaped), student and teacher journal reflections, and interviews with the participants' principals (recorded and transcribed). These data were informed by a previous four-year extensive data collection period of the five participants as they proceeded through their undergraduate reform-based teacher preparation program.

We collected and analyzed the data through the use of the qualitative technique of analytic induction to construct patterns of similarities and differences between the participants (Bogdan & Biklen, 1992; LeCompte, Millroy, & Preissle, 1992). This procedure involved careful reading of all textual data (e.g., interview transcripts and observation field notes) to develop a more global perspective of the data. For this study, we examined the data and came to consensus conclusions. Disputes were negotiated by appeal to evidence in the data collection. Exemplar participant quotes were selected to illustrate our findings and assertions.

Participants and Research Sites

First year: 4 women, 1 man; 1 Asian-American, 4 Whites; 1 non-traditional in age; 3 with upper elementary teaching positions, 2 with middle level positions-1 in mathematics, 1 mathematics/science. The five participants taught in 3 elementary and 2 middle schools. Second year: 3 women, 1 Asian American, 2 Whites; 2 with upper elementary teaching positions, 1 with middle level positions-mathematics/science). The continuing three study participants taught in 2 elementary and 1 middle school. See Tables 9 and 10 for a complete presentation of the school demographics and student criterion examination results. What follows is a brief description of each participant and school context (pseudonyms used in all cases).

Ms. Susan Lee is an Asian American woman, a traditional college student, finishing her degree in four years. She participated in one summer MCTP research internship at a space and aeronautical lab. Ms. Susan Lee taught fourth grade at Overlook Elementary School. Overlook Elementary School had not met any of the local standards on the district's criterion referenced tests. The school was attended by 42.2% Hispanics, 28.5% African Americans, 21.2% Whites, and 7.6% Asian. Sixty-two point two percent of the students received free or reduced meals. The school's mobility rate was 24.1%.

Mrs. Laura Kern is a White woman, a non-traditional college student who attended and transferred from numerous colleges and universities as she completed her undergraduate education degree. She completed her four-year degree in her mid-twenties. Mrs. Kern completed a summer MCTP research internship at an oceanside environmental education center run by the National Park Service. Mrs. Kern developed curriculum and ran daily programs for the park. Mrs. Kern transferred schools after her first year to accommodate the far away location of a newly purchased home. The school where she taught third grade her first year was Rock Hill Elementary. The school was over half African American (55%) and almost a quarter Hispanic (24.2%). Asian students and white students made up 8.5% and 11.9% of the population respectively. Over half of the students (59.5%) received free or reduced meals. The school had a 37.4% mobility rate, which was the highest of the six schools where our five participants were employed. The school had not met any of the district's grade appropriate criterion referenced test standards. Mrs.Kern taught fifth grade at her second school, Rider Elementary. That school also had not met any of the district's grade appropriate criterion referenced test standards. The school's population was 53.1% White, 21.6% African American, 16.7% Asian and 8.7% Hispanic. Twenty-four percent of the population received free or reduced meals.

Ms. Katie Phillips is a White woman, a traditional college student who finished her undergraduate degree in four years. She participated in one summer MCTP research internship at a science curriculum writing organization coordinated through the county where she is presently employed. The summer after her internship experience, she was employed by the organization as a curriculum writer. Ms. Phillips was employed at East View Middle School to teach both eighth grade mathematics and science. East View's population was composed of 64.9% white, 14.1% African American, 13.9% Hispanic and 6.9% Asian. Seventeen point one percent of the population received free or reduced meals. The school met four of the six standards for the district's criterion referenced tests. The students had not met the standards in sixth and eighth grade math.

Mr. Mark Jones is a White man, a non-traditional college student who returned to the University to complete his undergraduate education career after spending his early twenties working in the business world. He did not participate in a summer MCTP research internship (he was excused by the MCTP program due to his exceptional need to earn a summer salary for his family). Lincoln Middle School employed Mr. Jones for the first year of the study. Mr. Jones worked one year teaching eighth grade mathematics at Lincoln Middle School. After he completed his first year, he moved out of state to an American Indian Reservation where he is presently teaching science and serving as a school administrator. Of Lincoln's 6-8 graders, 38.3% were White, 30% were African-American, 20.6% were Hispanic, and 11.4% were Asian. Almost a third of the students (30.2%) received free or reduced lunches. The school failed to meet the local standard on the district's criterion reference test except for the sixth grade reading tests in which 76% of the students met the standard.

Ms. Mary McDonald is a White woman, traditional college student who finished her degree in four years. She participated in one summer MCTP research internship at an informal education curriculum development organization. She is presently teaching her second year at Glen Oaks Elementary School. Ms. McDonald taught fourth grade both years at the most affluent school site in our study, Glen Oak. Only 6.6% of the students received free or reduced meals. The school's population was

62.5% White, 29.1% Asian, and 5.9% African American and 2.3% Hispanic. The school's population had the lowest mobility rate of the study's six schools, (9.8%). The school also had met all the local standards with the exception of fourth grade mathematics on the district's criterion referenced tests.

Literature Review

The induction of science and mathematics teachers is of great interest to the mathematics and science education community, as well as to the larger community concerned with teacher preparation. Brown and Borko (1992) reviewed extensively the literature on becoming a mathematics teacher through the learning, socialization, and developmental theoretical perspectives. Ryan (1986) and Spector (1989) described and categorized the stages of a science teacher's career. The stages each proposed have some similarities and some differences associated with them.

In summary, Brown and Borko (1992)'s examination of the learning perspective emphasized three teacher knowledge bases hypothesized by Shulman (1986, 1987). Content knowledge, i.e., knowledge of subject matter, pedagogical knowledge, i.e., knowledge of subject matter for teaching, and pedagogical reasoning knowledge, i.e., the process of transforming content knowledge into pedagogically powerful forms appropriate for diverse learners, were all seen as necessary for novice mathematics teachers to possess before they could become successful expert mathematics teachers. The teacher socialization perspective proposed that external forces influenced new teachers as they were inducted into practice. Studies in this genre ranged from functionalist (i.e., the context determined the outcome) to interpretative and critical (i.e., the individual takes an active role in making sense of the context and modifying influences). Finally, the teacher development perspective supposed that a new teacher's development results from changes in cognitive structures, i.e., thinking patterns. While some advocated general patterns in development characterized by being "hierarchical, sequential, and invariant in order" (p. 232), Brown and Borko (1992) disagreed. They suggested that while different developmental stages can be argued to exist when comparing teachers, the different stages were not necessarily based on teaching experience or age.

Ryan (1986) proposed four stages of a science teacher's career: the fantasy stage, the survival stage, the mastery of craft stage, and the impact stage. Special needs, difficulties, and strengths characterized each. Ryan's stages were based on the empirical work of Frances Fuller (1969). These stages are the fantasy stage, the survival stage, mastery of craft stage, and the impact stage.

Beginning teachers fall into Ryan's (1986) fantasy and survival stages and into Spector's (1989) induction stage. The problems of those teachers, the consequences of their difficulties, and an intertwining of research on learning to teach with that on induction is included in the next portion of the literature review.

Perceived Problems of New Teachers. In an often cited study of the problems of first year teachers, including those knowledgeable in science into extant practices, Veenman (1984) acknowledged the "dramatic and traumatic" nature of the transition from preservice training to the first teaching job (p. 143). He termed that transition "reality shock," a concept used "to indicate the collapse of the missionary ideals formed during teacher training by the harsh and rude reality of everyday classroom life" (p. 143). Veenman cited Müller-Fohrbrodt, Cloetta, and Dann (1978) who suggested five indications of reality shock found in new teachers: in their perceptions of problems, in changes of behavior, in changes of attitude, in changes of personality, and in their leaving the teaching profession.

Eight perceived problems of beginning teachers in general are discipline, motivating students, dealing with individual differences, assessing students' work, relationships with parents, organization of class work, insufficient or inadequate teaching materials, and dealing with problems of individual students. Wanting to go beyond a listing of problems, Veenman suggested three frameworks that can be

used to examine such teacher difficulties: a developmental stages framework, a cognitive development framework, and a teacher socialization framework. Those ways of viewing the development of new teachers all attempt to explain individual changes and are complementary. Together they give a more complete picture of the needs of beginning teachers and lead to possible programs and plans for support of those in their induction years.

Problems of Beginning Teachers. Ryan (1986) suggested six common problems experienced by new teachers: with the "shock of the familiar," with students, with parents, with administrators, with fellow teachers, and with instruction. The "shock of the familiar" characterizes the adjustment that must be made by people who have been students for years but are now facing the multiple demands and responsibilities that accompany their new role as teacher, not student, in the classroom. Problems with students are of (at least) three types: understanding students and their needs, establishing an appropriate "social distance" from students, and discipline. Discipline problems arise because beginning teachers have a "highly romantic view of students" (p. 20), because of their own "quest for approval" (p. 21), and because of their inexperience and lack of skill.

Problems with parents may have several sources including teacher inexperience leading to parent apprehension, parent jealousy, and a teacher's lack of understanding of the pressures of parents' lives. They may be based in part on the fact that "teachers in training do not think about parents very much" (p. 22). Problems with administrators may be caused by the different roles and perspectives of administrators as well as on teacher problems with authority. Problems with fellow teachers may arise because of jealousies and "turf" protection, from social differences in a faculty group, and because a "new teacher will change the status system and reward structure of the school" (p. 27). They may well be a function of the fact that teaching is a high stress job, the demands and pressures are many, and interpersonal relations often suffer as a result.

Consequences of Problems of New Teachers. Ryan (1986) dealt quite specifically with the costs of difficulties of beginning teachers for many in the educational community. He emphasized the negative effect on student learning that is a consequence of a new teacher's struggles. He mentioned the problems for parents who are striving to protect their child's best interests and for administrators who must deal with both the consequences on student learning and parental concerns. Administrators must also be involved when discipline breaks down in a new teacher's classroom both in dealing with individuals and in advising the teacher on ways to restore order.

In addition to consequences of beginning teacher difficulties for others, there are costs for the individual teacher. The so-called "curve of disenchantment" (Ryan, 1986, p. 8) can, and often does, lead teachers to leave the profession.

Findings

Our elementary and middle level mathematics and science teachers entered the workplace with the capabilities and intentions to enact reform-based practices. They placed a high value on their reform-based teacher preparation program. Our finding differs from what Simmons, et.al(1999) reported in their study of beginning teachers' beliefs. Our analysis of how the new teachers taught and what they thought about while teaching in their first years of teaching suggests several ways that their practices may be strongly influenced by their perspectives of school culture. This finding supports an emerging body of research that posits "schools have served as powerful discourse communities that enculturate participants (students, teachers, administrators) into traditional school activities and ways of thinking (Putnam & Borko, 2000). In school cultures in which the new teachers believed they were supported by powerful members of the culture to enact reform, they flourished (e.g., Ms. McDonald and Ms. Lee). However, similarly to Lacey (1977) (as cited in Veenman, 1984, p. 163) in less supportive school

cultures we found that as our new teachers became enculturated (or socialized) into their schools, they implemented "social strategies" to respond to perceived constraining structures. Social strategies are action individuals take in reaction to perceived coercive power in a community setting. The social strategies the new teachers developed were *resistance, moving on, and exit.* These strategies were not mutually exclusive, but were used as the new teacher's thought appropriate in response to specific instances of perceived power in their school cultures.

Resistance. In several instances the new teachers expressed resistance in their actions toward traditional ways of thinking about mathematics and science teaching they detected in their school cultures. For example, in Ms. Kern's second school culture, her principal placed an emphasis on an increase of instructional time devoted to district instructional outcomes testing. This conflicted with Ms. Kern's view of how to use instructional time for student-focused activities. Her social strategy was to question her principal in a staff meeting about his perspective. She stated,

> My principal, or someone else, has formulated that according to the children last year who took the [statewide standardized exams], all the children who were every quarter at that 2/3 mark on the district instructional outcomes or better or higher, met proficiency on [the statewide test. So he's saying that this year that should be our goal. But it's a different set of children, was my argument to him. And he said, "Well, I guess mathematically speaking, you're right. But there's no harm for you guys to set that as a goal for your class."

In another example, in Ms. Lee's case when several veteran teachers reacted negatively to some of her reform-informed ideas, Ms. Lee spoke defended to them her reform-based practices. She stated,

> We had a team meeting, and they [her teacher teammates] came up to me, and they just said, I mean, of course they were positive at first, I mean, we get along very well, but then they're starting to say things like, they think that my method is just a little bit, well, they think they *cover* [participant's emphasis] more things. I said, "Well, you may cover more things and they may remember it short-term, like on short term to take a test, but what about later on when you're building from it?"

Moving on. In one case when the perceived instances of coercive power became preponderance, the new teacher began to consider options on how to stay in teaching within her school district but leave the immediate school culture. The new teacher's social strategy to improve her situation in a school culture that she (Ms. Phillip) found problematic, was to consider transferring within district, moving on, to another school[1]. She stated,

> But this, I mean, maybe somewhere else. Maybe I'd like to transfer schools. But I think that the emphasis coming down from the top down is just not where I want it to be.

Exit. Finally, in our examination of five new teachers, a social strategy that one took was to remain in teaching but to leave the larger context of his school culture, district, and state[2]. Mr. Jones' social strategy in a situation that he found overwhelmingly constraining was to exit his school, district,

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[1] In the spring 2000, Ms. Phillips informed the researchers that she was transferring schools, beginning in the fall 2000, to another middle level school in her district. She was pleased to share that she would be "teaching 8th grade science in my own classroom!" (Ms. Phillips, personal communication)

[2] Another social strategy that Ms. Phillips was beginning to consider, but not enacted was to *depart* teaching as a career. She stated,

> I know that one of the things that MCTP is concerned about is keeping teachers in teaching and making them want to stay. But I just don't know if this is what I'm going to want to do forever. I just can't tell. I cannot foresee myself doing this when I'm 40 years old. I just can't.

and state for another teaching position out of state on a Native American Reservation. From his principal's perspective, Mr. Jones' social strategy was unfortunate. He stated,

> Mr. Jones may have been a year too early arriving in our math program. I think our math curriculum [during Mr. Jones' first year] did not support what the Third International Math and Science studies supports or what I believe your program [MCTP] supports. However, this year in 6th grade, the year that Mr. Jones will not be here, we are going to institute a pilot program of a new curriculum called Connected Mathematics, which is a well-respected innovative curriculum received by the National Science Foundation Awards. We're going to pilot that program here at my school, which I thought would have been very consistent with your program goals.

Conclusion and Implications

We draw several implications from this study of new teachers' practices in different schools in the same school district.

First, our research suggests that a reform-oriented mathematics and science teacher preparation program can recruit, educate, and graduate a cadre of new teachers who are employed by school districts. Our rich documentation presents evidence (survey and case study) that new teachers from such a teacher preparation program have the capabilities and intentions to teach mathematics and science in a reform-based manner that makes connections between the disciplines by using high quality science mathematics.

Second, our research suggests that the school context in which the new teachers began their teaching practices is a major factor in whether reform-aligned mathematics and science teaching is regularly implemented. The supports and constraints an individual teacher encounters on a daily basis, particularly from individuals with potential coercive power over their work lives, are noticed by new teachers and influence their curricular, instructional, and assessment actions.

For example, in the cases of Ms. Lee, Ms. Kern (1st year) and Ms. McDonald, when the new teachers perceived support for how they intended to teach by the school cultures (with the primary determinants being the principal, the students' parents, and the district's curricula), the result was favorable for reform-based practices in mathematics and science. In the cases of Mrs. Kern (2nd year), Ms, Phillips, and Mr. Jones, when the new teachers perceived a mismatch between how they intended to teach and the school cultures (with the primary determinants being the district's curricula and assessment), the result was not favorable for reform-based practices.

Finally, if our findings are supported by future research, to enact reform and to retain new reform-prepared teachers a key implication is that new teachers fare better when they are employed in supportive, reform-oriented school cultures rather than in other environments. While our findings indicate that in situations in which reform-based teaching is discouraged some reform-prepared new teachers do not leave but elect to continue their careers in teaching by altering their practices to fit in with extant traditional practices, the loss of reform in those contexts is a costly impact. We posit that if better matches are made initially between reform-prepared teachers and school cultures, the extent and the quality of reform-based practices in mathematics and science teaching will increase as will the retention of more newly prepared teachers within school cultures. We also wonder what can reasonably be done in teacher preparation to more adequately prepare new, reform based teachers to enact reform-based practices in school cultures that are not initially supportive?

In addition, although much literature on new teachers (particularly in science education) supposes that new teachers proceed in a similar developmental stages of concern manner (see Spector, 1989 and Ryan, 1986), our research points in a different direction, a socialization perspective that is increasingly prominent in the mathematics literature (see, Brown and Borko (1992) and others). The

socialization perspective offers a view of what potentially can happen in their induction years to newly prepared reformed-based teachers. This theoretical perspective underscores the need for additional attention toward alerting new teachers as to the potential consequences of accepting employment in different types of environments. Additionally, another consequence may be to argue for enhanced support for reform within school cultures by reform-oriented personnel within school cultures.

Conversely, when a principal inadvertently exposed a new teacher to administrative censure for not teaching in a traditional manner, the result was adverse. The new teacher, Mr. Jones, chose to leave his school and district rather than continue to continue employment in that school culture. Also, when a new teacher, Mrs. Phillips, determined the district recommended assessment structures to be in conflict with her construction of reform-based instruction and assessment, she increasingly began to consider transferring from her immediate school culture and reevaluating if teaching was a long term career choice.

Consequently, the major finding from this study is that while teacher preparation could send forth newly prepared "good seed" teachers, the primary limiting factor as to the long term extent and success of the new teachers in enacting reform was the school culture in which they practiced. School cultures (consisting of principals, teachers, students, student guardians, and district curricula and assessment demands) that actively supported and respected the reform-orientation of the new teachers resulted in the most contented, stable, and effective personnel. In non-supportive school cultures, the opposite resulted.

Finally, while we would like to attribute conclusively to the MCTP the positive aspects we observed and heard others mention of our participant teaching practices, we resist that temptation. Each of our participants was self-selected to the program and brought along individual talents, hopes, aspirations, and beliefs. Separating the impact of their reform-based teacher preparation program from what the participants brought to the program was not possible. However, we could document from multiple viewpoints how the MCTP new teachers have fared and were perceived by many of the players in their teaching cultures. An important finding was that the MCTP new teachers did intend to and did attempt, to varying levels of extent and success, the reform-based goals of the program. Their school cultures varied, however, in how nurturing and supportive they were in hosting reform-based instruction in mathematics and science.

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Author Note

This research was supported by two grants from the National Science Foundation's Collaboratives for Excellence in Teacher Preparation Program (CETP), DUE 9255745 and DUE 9814650.

We would like to gratefully acknowledge the generosity of the new teachers who participated in this study. The first years of teaching practice typically leave little room for additional obligations outside of immediate work obligations. We believe that their commitment to research as a way of professional development offers our profession one vision of how the world of work and academia can support each other during the induction years.

Appendix: **MCTP Teacher's Actions And Beliefs Of Mathematics And Science**

Directions: Please select the letter response that best represents your actions and beliefs.

SECTION I.
To what extent do you agree or disagree with each of the following statements?
Choices:

(A)	(B)	(C)	(D)
Strongly disagree	**Disagree**	**Agree**	**Strongly agree**

Mathematics
1. is primarily an abstract subject.
2. is primarily a formal way of representing the real world.
3. is primarily a practical and structured guide for addressing real situations.
4. should be learned as sets of algorithms or rules that cover all possibilities.
5. A liking for and understanding of students are essential for teaching math.
6. If students are having difficulty, an effective approach is to give them more practice by themselves during the class.
7. More than one representations should be used in teaching a math concept.
8. Some students have a natural talent for math and others do not.
9. Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.

Science
10. is primarily an abstract subject.
11. is primarily a formal way of representing the real world.
12. is primarily a practical and structured guide for addressing real situations.
13. Some students have a natural talent for science and others do not.
14. A liking for and understanding of students are essential for teaching science.
15. It is important for teachers to give students prescriptive and sequential directions for science experiments.
16. Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.
17. If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.
18. Students see a science task as the same task when it is represented in two different ways.

SECTION II.
To be good at mathematics [science] at school, how important do you think it is for students to [fill in the blank with each of the items below] ?
Choices:

(A)	(B)	(C)
Not important	**Somewhat important**	**Very Important**

In Mathematics
19. remember formulas and procedures?
20. think in sequential manner?
21. understand concepts?
22. think creatively?
23. understand math use in real world?
24. support solutions?

In Science
25. remember formulas and procedures?
26. think in sequential manner?
27. understand concepts?
28. think creatively?
29. understand science use in real world?
30. support solutions?

SECTION III.
What is your familiarity with the reform documents?
Choices:

(A)	(B)	(C)	(D)	(E)
Not at all	**Small extent**	**Fairly**	**Moderate extent**	**Great extent**

31. Mathematics standards document (Curriculum and Evaluation Standards for School Mathematics).
32. Science standards document Benchmarks for Science Literacy.
33. Science standards document National Science Education Standards.

SECTION IV.
Please indicate if you use (or would use if you taught mathematics and science) the instructional strategies listed below.
Choices:
(A) No **(B) Yes**

In Mathematics
34. Assisting all students to achieve high standards.
35. Providing examples of high-standard work.
36. Using authentic assessments.
37. Using standards aligned curricula.
38. Using standards-aligned textbooks and materials.
39. Using telecommunication-supported instruction.
40. Making connections with science.

In Science
41. Assisting all students to achieve high standards.
42. Providing examples of high-standard work.
43. Using authentic assessments.
44. Using standards aligned curricula.
45. Using standards-aligned textbooks and materials.
46. Using telecommunication-supported instruction.
47. Making connections with mathematics.

SECTION V
48. If you have taught since graduation, for what duration?
    a. in beginning year b. 1 to 2 years c. 3 to 4 years d. > 4 years
49. If applicable, what grade level are you teaching this year?
    a. 1 or 2 b. 3 or 4 c. 5 or 6 d. 7 or 8 e. other
50. If applicable, are you a specialized teacher (by content)?
    a. yes b. no
51. If you are a specialized teacher, what is your content area?
    a. mathematics b. science c. both mathematics and science d. other

The preparation of this instrument was supported in part by a grant from the National Science Foundation (Cooperative Agreement No. DUE 9255745).

Table 1
MCTP Teachers' Beliefs About The Nature And Teaching Of Mathematics And Science

Mathematics	**MCTP**	**National Sample**
Is primarily an abstract subject	6.3%	25%
Is a formal representation	71%	79%
Is a structural guide	75.8%	90%
Some students have a natural talent	71.9%	82%
Teachers need to like and understand students instructional strategies	81.8%	96%
Independent practice is effective for students	21.2%	22%
Multiple representations should be used in teaching	87.9%	98%
Learn as set of rules	28.1%	34%
Computational skills are enough for elementary teachers	21.2%	14%

Science	**MCTP**	**National Sample**
Is primarily an abstract subject	13.3%	18%
Is a formal representation	58.1%	84%
Is a structural guide	69.7%	90%
Some students have a natural talent	53.1%	62%
Teachers need to like/understand students	69.7%	90%
Students need prescriptive directions	56.3%	78%
Focusing on rules a bad idea	33.3%	32%
Debates in class harmful	12.1%	2%
Multiple representations should be used in teaching	40%	42%

Table 2

MCTP Teacher Perceptions Of Student Skills Required For Success In Mathematics And Science

Mathematics	**MCTP**	**National Sample**
Remember formulas and procedures	33.3%	43%
Think in sequential manner	54.5%	48.5%
Understand concepts	88%	93.9%
Think creatively	54.5%	65%
Understand math/science use in real world	90.9%	82%
Support solutions	87.9%	82%

Science	**MCTP**	**National Sample**
Remember formulas and procedures	24.2%	26%
Think in sequential manner	48.5%	80%
Understand concepts	87.9%	83%
Think creatively	60.6%	73%
Understand math/science use in real world	90.9%	79%
Support solutions	87.9%	87%

Table 3

MCTP Teachers' Instructional Strategies

Mathematics	MCTP	National Sample
Assisting all students to achieve high standards	93.9	85
Providing examples of high-standard work	90.9	66
Using authentic assessments	96.8	49
Using standards aligned curricula	87.5	72
Using standards-aligned textbooks and materials	81.8	80
Using telecommunication-supported instruction	66.7	72
Making connections with science	87.9	27

Science	MCTP	National Sample
Assisting all students to achieve high standards	93.9	78
Providing examples of high-standard work	90.9	64
Using authentic assessments	93.9	42
Using standards aligned curricula	87.9	65
Using standards-aligned textbooks and materials	84.8	78
Using telecommunication-supported instruction	81.8	60
Making connections with mathematics	87.9	29

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