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Changing Teacher Beliefs

PLCs in Guatemala

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Purpose Statement

The purpose of the National Journal of Mathematics Education Leadership is to advance the mission and vision of the National Council of Supervisors of Mathematics by:

- Strengthening mathematics education leadership through the dissemination of knowledge related to research, issues, trends, programs, policy, and practice in mathematics education
- Fostering inquiry into key challenges of mathematics education leadership
- Raising awareness about key challenges of mathematics education leadership, in order to influence research, programs, policy, and practice
- Engaging the attention and support of other education stakeholders, and business and government, in order to broaden as well as strengthen mathematics education leadership

Gauging the Relative Effects of Reform-Based Curriculum Materials and Professional Development in Promoting Changes in Teacher Beliefs

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Following the publication of the *Curriculum and Evaluation Standards* (NCTM, 1989), three influences emerged as primary vehicles in promoting the mathematics reform movement: professional development, curriculum materials, and assessment (Smith & O'Day, 1991). Numerous research studies have examined the effects of two of these influences—professional development and curriculum materials--in assisting teachers to adopt or transition to a reform perspective in their classroom practice (Anderson, 1995; Cai, Watanabe, & Lo, 2002; Chavez, Reys & Reys, 2004; Herbel-Eisenmann, & Wagner, 2005; Herbel-Eisenmann, Lubienski, & Id Deen, 2006; Hirsch, Lappan, Reys, & Reys, 2005; Lloyd, & Herbel-Eisenmann, 2004; Remillard, 2000;). As the reform movement has gained momentum through the influence of such documents as *Principles and Standards for School Mathematics* (NCTM, 2000) and *Adding it Up* (Kilpatrick, Swafford, & Findel, 2001) many mathematics educators have become interested in the interplay between the influence of professional development and the influence of curriculum materials—both based on a reform perspective. Several studies have instigated an examination of the interactive relationship between these two influences.

Collopy (2003) suggests that reform-oriented curricula even without accompanying professional development possess a transformative potential, but Orrill and Anthony (2003) offer a different perspective demonstrating that curriculum materials based upon reform pedagogy are ineffective in promoting reform unless accompanied by professional development. Cohen & Ball (2001) concur stating that, ". . . curriculum materials can not determine the curriculum of the classroom and innovative curricula alone can not produce instructional improvement." (p. 74) This conclusion is due to the wide variation inherent in curricular implementation (Chval, Grows, Smith, Weiss, & Ziebarth, 2006) which implementation is in turn dependent upon teachers' orientations towards the curriculum materials (Remillard & Bryans, 2004). Hence, Ziebarth (2003) concludes that the wise use of both curriculum materials and professional development are needed in promoting real reform.

Bay, Reys, and Reys (1999) posit that one way to synergize the influences of professional development and curricula is to provide the opportunity to select curriculum materials as part of professional development. Reys and Bay-Williams (2003) later observed an interactive relationship between these two influences and Remillard (2005) has developed a framework for examining teacher interaction with curricula. Questions still remain, however, concerning the relative effects of professional development and curricula. For example, which has a greater effect? If the influence of curriculum materials is marginalized without accompanying professional development, is the opposite condition also true, i.e., is the influence of professional development marginalized without the support for implementation offered by curriculum materials?

In conjunction with our professional development work, we conducted a quasi-experiment regarding the role of curriculum materials in affecting reform. We were teaching two groups of

elementary teachers in a two-year, school-wide professional development program consisting of 18 graduate level credits in mathematics content, curriculum, assessment, and pedagogy that leads to a license endorsement. One distinguishing characteristic between the two groups concerned the curriculum materials used by the teachers in each group. One group had been using a reform curriculum for five years, *Investigations in Number, Data, and Space* (TERC, 1998), while the other was using a more traditional text program. Many of the teachers in the former group also reported participating in district-sponsored workshops designed to support their use of Investigations. We therefore concluded that because both groups were receiving the same fundamental professional development, we were in a position to examine the relative effects of the use of two vastly different curricula in the context of professional development.

In order to examine the effects of these differing curricula, we decided to focus on teacher beliefs. Beliefs are frequently defined as dispositions to act (Cooney, Shealy, & Arvold, 1998) and have become a common way to examine the effects of mathematics teacher education practices (Civil, 1993; Mewborn, 2000; Pajares, 1992; Vacc & Bright, 1999).

Philipp, et. al. (2007) developed a set of seven beliefs that reflect a current reform perspective and have categorized them under three main headings: beliefs about mathematics, beliefs about learning or knowing mathematics, and beliefs about children's learning and doing mathematics. The beliefs are listed as follows:

Belief About Mathematics

1. Mathematics is a web of interrelated concepts and procedures (and school mathematics should be too).

Beliefs About Learning or Knowing Mathematics, or Both

2. One's knowledge of how to apply mathematical procedures does not necessarily go with understanding of the underlying concepts.
3. Understanding mathematical concepts is more powerful and more generative than remembering mathematical procedures.
4. If students learn mathematical concepts before they learn procedures, they are more likely to understand the procedures when they learn them. If they learn the procedures first, they are less likely ever to learn the concepts.

Beliefs About Children's (Students') Learning and Doing Mathematics

5. Children can solve problems in novel ways before being taught how to solve such problems. Children in primary grades generally understand more mathematics and have more flexible solution strategies than adults expect.
6. The ways children think about mathematics are generally different from the ways adults would expect them to think about mathematics. For example, real-world contexts support children's initial thinking whereas symbols do not.
7. During interactions related to the learning of mathematics, the teacher should allow the children to do as much of the thinking as possible.

Therefore, we were interested in how the use of different curricula could affect changes in the above beliefs among the teachers in our two professional development groups. Our research question became: How does the use of differing curriculum materials affect the belief changes of teachers involved in professional development? Specifically, we asked these questions in order to address our overall research question:

1. How did the teachers' beliefs in the two groups differ prior to the professional development?
2. How did those beliefs change in the course of the professional development?
3. How did the teachers' beliefs in the two groups differ after one year of professional development?

Method

Because the use of a reform curriculum was, in effect, a treatment of sorts, and because the subjects were not randomly assigned to groups, a Nonequivalent Pretest-Posttest Control Group Design (McMillan & Schumacher, 1984) was used to investigate our research question. There were 15 teachers who used a reform curriculum, referred to in this paper as the "Reform Curriculum Group" and another 15 teachers who used a more traditional curriculum, referred to as the "Traditional Curriculum Group." The teachers in each group taught in elementary schools within different school districts but within the same general intermountain area.

As mentioned previously, each group was engaged in essentially the same two-year, 18-credit hour professional development program leading to a license endorsement. This program consisted of two-hour, graduate level courses in pedagogy, assessment, curriculum, child development related to mathematics, technology, and two four-hour courses in mathematics content. Participants were given readings in mathematics education research and research-

based materials (e.g., *Beyond Classical Pedagogy*, Wood, Nelson, & Warfield, 2001), engaged in numerous class-based activities (e.g., mathematical investigations, case studies, discussions, video analyses), and assigned reflective and research papers of various sizes and purposes, all focused on application to classroom practice. Many of the participants were also enrolled in a Master's Degree program for which the professional development courses served as credit.

The *Integrating Mathematics and Pedagogy (IMAP) Survey* (Philipp, et. al., 2007) was used to measure the degree or intensity to which respondents possess the seven beliefs identified. It presents written or video cases to which teachers are asked to respond. The responses are then analyzed via rubrics based on three-, four-, or five-point scales thus allowing for inferences to be made about the intensity of the beliefs held by those taking the survey. The following is an excerpt from the browse version of the survey available at http://www.sci.sdsu.edu/CRMSE/IMAP/pubs.html (IMAP: Integrating Mathematics and Pedagogy Publications/Presentations [Browse the Survey], retrieved September 21, 2007).

> (Respondents view a video in which a teacher uses a "teaching as telling" process to teach a child the procedure for dividing fractions.)
>
> 9.1 Please write your reaction to this videoclip. Did anything stand out for you?
> 9.2 What do you think the child understands about division of fractions?
> 9.3 Would you expect this child to be able to solve a similar problem on her own 3 days after this session took place? Explain your answer.
>
> (Respondents now view another videoclip in which the same teacher asks the same child to solve another dividing fractions problem and the child has no idea on how to do so.)
>
> 9.4 Comment on what happened in this video clip. (NOTE: This interview was conducted 3 days after the previous lesson on division of fractions.)
> 9.5 How typical is this child? If 100 children had this experience, how many of them would be able to solve a similar problem 3 days later? Explain.
> 9.6 Provide suggestions about what the teacher might do so that more children would be able to solve a similar problem in the future.

Of interest is the fact that the IMAP Survey was designed for use with preservice students. We are among the first researchers to use it in gauging belief changes in the context of work with inservice teachers (see Bahr & Monroe, 2008)

We invited the teachers to complete the survey twice — once after a year of professional development that served as a post-measure, and then a second time in a retrospective manner (i.e., to complete it as if they were doing so prior to our professional development work). Cantrell (2003) demonstrated the validity of retrospective pre-measures in assessing the beliefs of preservice students. These measures address the problem of response-shift bias (Aiken & West, 1990; Cronbach & Furby, 1970), and as a result, tend to produce gain scores with greater validity and greater statistical power (Bray, Maxwell, & Howard, 1984; Howard et al., 1979). Therefore, we felt justified in the use of the survey in our work with inservice teachers. We could have waited until the second year to administer the survey as a post-measure, but were anxious to examine the effects of our work after the first year in order to further inform our professional development work.

Results

This section will be organized according to the research questions previously outlined.

How did the teachers' pre-professional development beliefs in the two groups differ? We first analyzed the group means obtained from the retrospective pre-survey scores using an analysis of variance to determine whether or not there were pre-existing differences between the two groups relative to any of the seven beliefs. Inasmuch as the data obtained from the survey is not ordinal, but rather interval in nature, the use of distribution-dependent statistical procedures, such as t-ratios, would ordinarily be inappropriate tools for analysis. However, Philipp, et. al. (2003) demonstrated the validity of using these distribution-dependent procedures for analyzing data obtained from the Beliefs Survey. He did so by analyzing differences between groups via the Beliefs Survey using a polychotomous log-linear ratio method and then re-analyzing those differences using t-ratios. Both analysis procedures eventuated in discovering the same number of significant differences between the groups he studied. Therefore, because distribution-dependent analyses are more commonly used in quantitative studies and thus are more commonly understood, and because they have been shown to yield the same statistical conclusions with data obtained from the Beliefs Survey, we used them for purposes of our study.

Table 1 displays the results of those analyses, and not surprisingly, the means obtained from the reform curriculum group differed significantly from the traditional curriculum

Table 1. Comparisons of Pre-Survey Means for Reform Curriculum and Traditional Curriculum Groups

		Group Means				
Belief	Rubric Range	Reform Curriculum Group	Traditional Curriculum Group	df	F	*p*
1	0-4	1.067	0.188	29	8.96	.005
2	0-5	0.733	0.813	29	0.04	.843
3	0-4	2.800	0.313	29	100.4	<.001
4	0-4	2.667	0.500	29	45.17	<.001
5	0-5	2.333	0.5623	29	22.51	<.001
6	0-5	2.533	0.563	29	36.84	<.001
7	0-4	1.333	0.375	29	5.88	.022

group on six of the seven beliefs in favor of a more reform-oriented perspective.

How did those beliefs change in the course of the professional development? We compared the pre- and post-belief score means of each group using an analysis of variance procedure in order to determine if the teachers within each group experienced significant belief changes. The results are displayed in Tables 2 and 3.

As shown, a change in belief toward a reform perspective occurred in relation to three beliefs in the case of the reform curriculum group. We wondered about whether or not there might be some sort of ceiling effect that would preclude documenting actual belief changes since the pre-professional development means of this group were much higher than those of the traditional curriculum group. However, these means are far below the upper end of each scale, except in the case of belief 4, and a significant difference in relation to belief 4 was observed. In the case of the traditional curriculum group, significant differences between pre and post means were observed in relation to all seven beliefs. These observations lead us to wonder if our professional development work was more effective for teachers who are initially less-reform minded, or if greater belief changes might have been observed had we waited until the end of the two-year professional development program to administer the survey. We will discuss these issues more completely in the "Discussion" section of this article.

How did the teachers' beliefs in the two groups differ after one year of professional development? We then analyzed

Table 2. Comparisons of Pre- and Post-Means for Reform Curriculum Group

		Means				
Belief	Rubric Range	Pre	Post	df	F	*p*
1	0-4	1.067	1.733	28	2.32	.029
2	0-5	0.733	1.533	28	0.04	.028
3	0-4	2.800	3.067	28	.93	.361
4	0-4	2.667	3.533	28	3.13	.004
5	0-5	2.333	1.733	28	-1.46	.155
6	0-5	2.533	2.667	28	36.84	.698
7	0-4	1.333	1.533	28	5.88	.664

Table 3. Comparisons of Pre- and Post-Means for Traditional Curriculum Group

		Means				
Belief	Rubric Range	Pre	Post	df	F	*p*
1	0-4	0.188	1.563	28	5.69	<.001
2	0-5	0.813	2.000	28	3.28	.003
3	0-4	0.313	2.800	28	8.59	<.001
4	0-4	0.500	3.333	28	10.12	<.001
5	0-5	0.563	2.188	28	4.09	<.001
6	0-5	0.563	2.667	28	36.84	<.001
7	0-4	0.375	1.813	28	5.88	.003

the group means obtained from the post-survey scores using an analysis of variance to determine if there were differences between the two groups relative to any of the seven beliefs after the first year of professional development. The results are displayed in Table 4. As shown, none of the differences between the means obtained from the groups relative to each belief were significant. This is especially meaningful when we recall that the means obtained from groups on the pre-survey differed significantly on six of the seven beliefs, an issue that is discussed further in the next section.

How did belief changes vary across groups? To address this question, we re-examined the data and related analyses previously discussed and created graphs as displayed in Figures 1-7. These graphs pictorially display the pre and post-survey means of each group. They clearly show that although the means obtained from the two groups

Table 4. Comparisons of Post-Survey Means for Reform Curriculum and Traditional Curriculum Groups

		Group Means				
Belief	Rubric Range	Reform Curriculum Group	Traditional Curriculum Group	df	F	*p*
1	0-4	1.733	1.563	29	0.31	.580
2	0-5	1.533	2.000	29	2.58	.120
3	0-4	3.067	2.800	29	0.77	.387
4	0-4	3.533	3.333	29	0.64	.429
5	0-5	1.733	2.188	29	1.24	.275
6	0-5	2.667	2.667	29	0.00	1.000
7	0-4	1.533	1.813	29	0.38	.543

differed significantly prior to professional development in relation to six of the seven beliefs in favor of the reform curriculum group, those differences disappeared by post-survey administration. This observation suggests that the traditional curriculum group experienced greater belief changes towards a reform perspective than those experienced by the reform curriculum group even though both groups ended with similar belief intensities. In addition, the reform curriculum group actually experienced significant change themselves in relation to three beliefs.

Figure 1. Pre-Post Cross Group Comparison — Belief 1

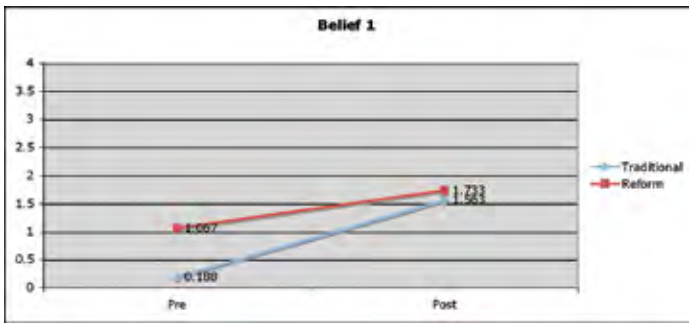
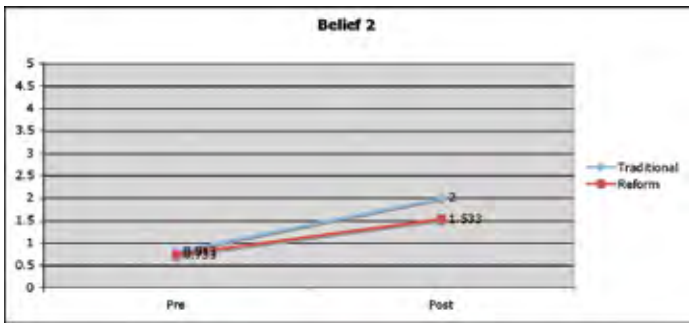


Figure 2. Pre-Post Cross Group Comparison — Belief 2



Conclusions

We will orchestrate this section of our article according to our questions and observations. To begin, our data confirms the work of many others about the effects of the use of reform-oriented curriculum materials. The beliefs possessed by the groups of teachers we engaged in professional development differed significantly prior to our work with them. Those who used reform curricula possessed beliefs that more closely approximated a reform perspective than those who used traditional curricula.

Figure 3. Pre-Post Cross Group Comparison — Belief 3

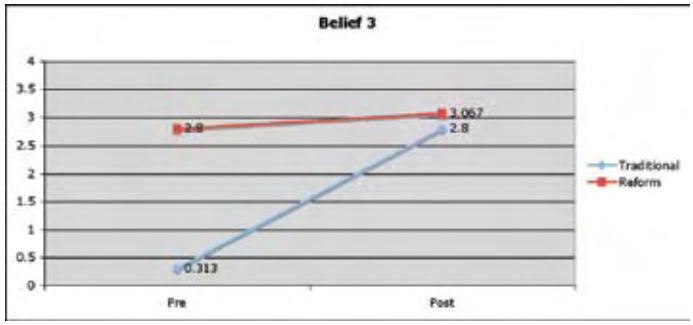


Figure 4. Pre-Post Cross Group Comparison — Belief 4

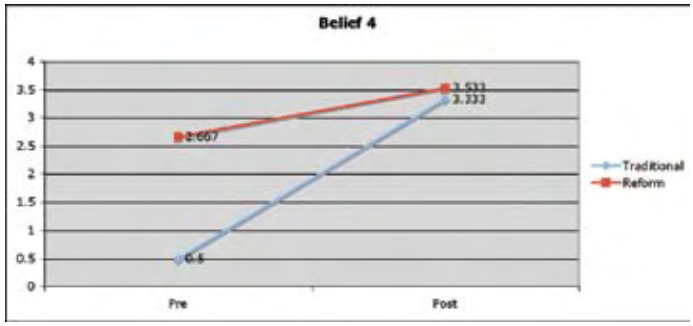


Figure 5. Pre-Post Cross Group Comparison — Belief 5

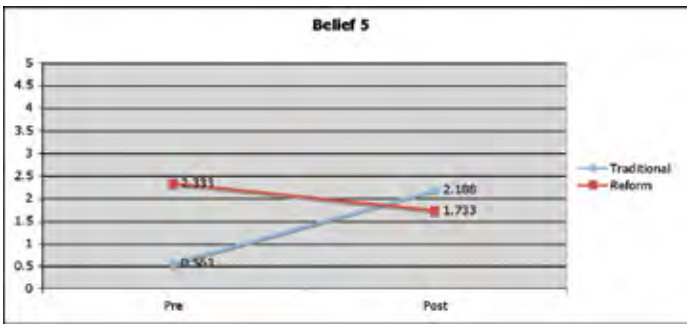


Figure 6. Pre-Post Cross Group Comparison — Belief 6

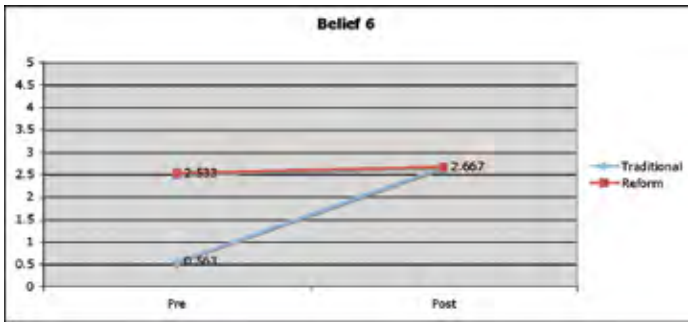
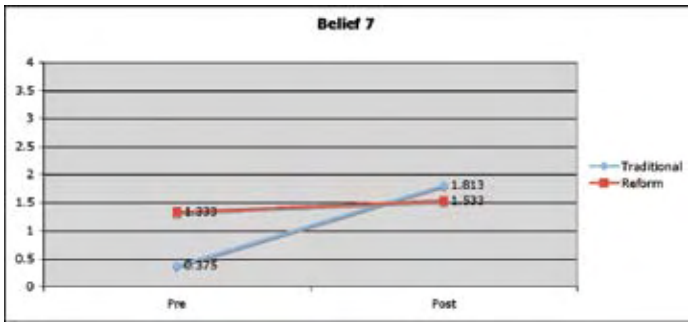


Figure 7. Pre-Post Cross Group Comparison — Belief 7



Second, because the teachers in both groups experienced belief changes, we conclude that our professional development efforts had some effect, which supports the conclusions of Orrill and Anthony (2003).

Third, inasmuch as both groups received the same basic professional development, and that the traditional curriculum group experienced greater changes in the intensity of their beliefs, we wondered about the relative influence of professional development together with curriculum materials. Despite the lack of reform curricula, the beliefs of the teachers in the traditional curriculum group "caught up" with those possessed by the teachers in the reform group. We find this result especially interesting in light of the previously-mentioned observation that several teachers in the Reform Curriculum Group reported participating in district-sponsored workshops designed to support their use of *Investigations*. It seems logical to conclude, therefore, that because pre-existing belief differences disappeared by the time of the post measure, professional development, or at least, our professional development work, might actually be more powerful in promoting belief changes than the use of reform curricula. Other alternative conclusions are also possible.

For example, these observations lead us to wonder, as previously mentioned, if our professional development work was more effective for teachers who are initially less-reform minded, particularly in the first year. It is entirely possible that differing belief changes may occur during the second year of the professional development program. Perhaps the reform curriculum teachers may experience an accelerated change as a result of the second year course work paralleling the change experienced by the traditional curriculum teachers during the first year. Then two additional scenarios may result. If the traditional curriculum teachers continue the same rate of change or even a greater rate than the rate experienced in the first year, then the change in beliefs experienced by both groups during the second year would parallel each other, again supporting the conclusion that professional development is more powerful than curriculum materials in promoting belief changes. If, on the other hand, the traditional curriculum teachers experience a slower rate of belief change while the reform teachers experience an acceleration, we might conclude that curriculum materials have a greater influence than we suspect. It is possible that the changes that potentially occur because of use of a reform curriculum have an end point—that is, that the use of a reform curriculum can only change teacher beliefs to a certain degree without professional development.

All in all, our research seems to support the conclusion of Ziebarth (2003) that the wise use of both curriculum materials and professional development are needed in promoting real reform.

Connecting to Future Research

This study and those which have preceded it have addressed questions regarding the reform-mindedness (RM) of teachers' beliefs, and the changes therein resulting from teaching with reformed curricula, RM professional development, and a combination of the two. Clearly, however, many options have not yet been considered in this research.

Nuanced time frames should eventually be investigated. For instance, will a teacher who receives no RM professional development, but uses a reformed curriculum eventually gain RM, and if so how long may it be expected to take? Or will a teacher who participates in RM professional development but uses non-RM curricular materials eventually gain RM, and if so how long may it be expected to take. Questions of this

Table 5. Duration of Transition to Reform-Mindedness

				Reformed Professional Development				
				Yes				No
				Years of Experience				
				x	y	z	...	
Reformed Curriculum	Yes	Years of Experience	x	RM after *A* Years				RM after *B* Years
			y					
			z					
			...					
	No			RM after *C* Years				RM after *D* Years

sort can be generated from the accompanying table and future research should attempt to answer some of these questions. An added dimension of the level of RM prior to, during, and at the end of certain curricular usage and professional development experiences can be integrated into time frame investigations (as was investigated in this study).

Professional development may take many forms. Among many others, these include investigating curricular materials, analyzing and selecting curricular materials, and developing new curricular materials. This can be extended into the investigation of RM professional development. Thus, future research should consider if one of these or other forms of RM professional development more quickly and deeply leads to participant RM.

In the same light, it should be determined if some RM curricular materials naturally lead a teacher to become RM even without the addition of RM professional development and the nature of such curriculum.

Future research should investigate recidivism of non-RM of teachers who are not continually involved in RM curriculum and/or professional development. Furthermore, significant research should continue to differentiate between teachers who claim to be RM and those who have instructional practices which are decidedly non-RM.

Summarily, many other issues warrant future investigation regarding the development and maintaining of RM among mathematics teachers. It is hoped that as this study has addressed some of these questions, research will continue to delve into the many other questions listed herein. Nevertheless, this study has demonstrated that teacher beliefs can be changed to RM when the professional development has such a goal.

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