PROFESSIONAL DEVELOPMENT AND KNOWLEDGE GAINS FOR HIGH SCHOOL MATHEMATICS TEACHERS

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This study examined the effects of the Local Systemic Change Through Teacher Enhancement Initiative (LSC) on 1,596 in-service high school mathematics teachers' knowledge. Because data are clustered by schools, a hierarchical linear model was calculated. It was found that five of the characteristics of the professional development, time to reflect, support to implement, hours attended, assistance to implement from LSC, and participation in message boards, had statistically significant effects on increasing teacher knowledge, but time to work with other teachers, race, educational background, and years taught did not have a statistically significant effect.

Keywords: High School Education, Teacher Knowledge

Introduction

There are many different ideas about what makes professional development effective, but there is some agreement on what key features are important (Borko, 2004; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001; Heck, Banilower, Weiss, & Rosenberg, 2008). Desimone (2009) argues for her Core Conceptual Framework with five key features of professional development that are content focus, active learning, coherence, duration, and collective participation, and that these key features lead to an increase in teacher knowledge. In the Eisenhower professional development programs, Garet et al. (2001) found that focus on content knowledge, active learning, and coherence were all statistically significant predictors of enhanced knowledge and skills when controlling for sponsor, traditional or reform, span, and contact hours.

Between 1997 and 2006, the National Science Foundation funded 86 professional development projects, 48 of which were for math teachers, across the country through the Local Systemic Change Through Teacher Enhancement Initiative (LSC) (Heck et al., 2008). According to Heck et al. (2008), the main goals of the LSC projects were to include all teachers in targeted schools with a minimum of 130 hours of professional development and to implement LSC-designed curriculum materials in the teachers' classrooms. The individual projects were designed to include key features of effective professional development, but the main focus was to increase teachers' content knowledge, pedagogical content knowledge, and the use of investigative pedagogical strategies (Heck et al., 2008). To assess these outcomes, teachers were expected to complete a questionnaire at the end of a year of participation in the LSC project (Heck et al., 2008).

Research Question

What factors of an LSC professional development for high school math teachers predict perceived increase in knowledge by the teacher?

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Method

Data

The data was collected from the National Science Foundation's Local Systemic Change through Teacher Enhancement Initiative (LSC). This project offered professional development for K-8 and 6-12 teachers in mathematics and science over the school years 1996-97 to 2005-06 (Banilower, Heck, & Weiss, 2007; Heck et al., 2008). Each year of the project, principals and teachers were required to complete a Principal Questionnaire or Teacher Questionnaire, with a response rate of 80% expected for the teachers and 90% expected for the principals (Heck et al., 2008). Several of the questions in the questionnaires changed in the initial two years, but the questions stabilized by the third year (Heck et al., 2008). For questions that were changed, data from later questionnaires were both recoded to the original scale and included in the new scale with missing values for the original questionnaires. The data set is available by request from Horizon Research.

Participants

The full data set included over 80,000 participants' responses to the four teacher questionnaires, K-8 math, 6-12 math, K-8 science, and 6-12 science, but the data were filtered to focus just on the 9-12 math teachers which left 3,064 of the full data set. Removing any participants who were missing data for the variables of interest left 1,596 teachers in the sample data to be analyzed.

The participants are all 9-12 mathematics teachers who took part in LSC professional development. The participants are split almost evenly between males (45%) and females (55%). The participants are primarily white (80%), with other races under 10% (black). For educational background, the majority had an undergraduate major in mathematics or mathematics education (60%) and certification to teach (60%). Additionally, a large percentage held a graduate degree in mathematics or mathematics education (38%). On average, the participants had 12.30 years of teaching experience.

Table 1: Descriptive Statistics of Teacher Control Variables by Sample and Original Data

	Sample Data						Original Data				
	M	SD	Min	Max	N		M	SD	Min	Max	N
Male	.43	.50	0	1	1,596		.45	.50	0	1	3,023
Hispanic	.03	.17	0	1	1,596		.03	.18	0	1	3,064
Indian	.01	.11	0	1	1,596		.01	.11	0	1	3,064
Asian	.02	.15	0	1	1,596		.03	.17	0	1	3,064
Black	.09	.29	0	1	1,596		.10	.31	0	1	3,064
Pacific Islander	.00	.04	0	1	1,596		.00	.03	0	1	3,064
White	.83	.37	0	1	1,596		.80	.40	0	1	3,064
No Race Indicated	.02	.14	0	1	1,596		.03	.17	0	1	3,064
Undergraduate Major	.61	.49	0	1	1,596		.60	.49	0	1	3,020
Undergraduate Minor	.10	.30	0	1	1,596		.10	.30	0	1	3,020
Graduate Major or Minor	.38	.49	0	1	1,596		.38	.49	0	1	3,020
Teaching Certificate	.63	.48	0	1	1,596		.60	.49	0	1	3,020
None of the Above Education	.07	.26	0	1	1,596		.08	.27	0	1	3,020
Years Taught	11.86	7.67	1	21	1,596		12.30	7.79	1	21	3,038

Note. $N = 3{,}064$ for the original data and $N = 1{,}596$ for the sample data. Years taught is on a scale of 1 to 21+ years, with the maximum coded as 21. For all other variables, 0 indicates "no" and 1 indicates "yes."

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For the original data set, the data are nested within 19 professional development projects with a range of 1 to 400 participants in each project. There mean number of teachers per project is 161.26 with a standard deviation of 117.94. For the sample data, the data are nested within 18 professional development projects with a range of 3 to 223 participants in each project. There are a mean number of 88.67 teachers per project with a standard deviation of 61.74.

Table 2: Descriptive Statistics by Project ID by Sample and Original Data

	Sample Data			Original Data	
Project ID	Count	Percent		Count	Percent
04	56	3.51		98	3.20
09	77	4.82		153	4.99
10	93	5.83		188	6.14
18	223	13.97		400	13.05
19	13	.81		16	.52
28	0	.00		1	.03
31	51	3.20		124	4.05
36	98	6.14		195	6.36
39	129	8.08		249	8.13
40	58	3.63		101	3.30
42	153	9.59		224	7.31
44	95	5.95		232	7.57
48	68	4.26		123	4.37
58	144	9.02		284	9.27
71	183	11.47		369	12.04
72	3	.19		8	.26
73	4	.25		11	.36
74	120	7.52		219	7.15
78	28	1.75		58	1.89

Note. $N = 3{,}064$ for the original data and $N = 1{,}596$ for the sample data.

Measures

The control teacher variables come primarily from the teacher questionnaire. The variables for gender and race are dummy variables created from participants choosing one of a list of choices, as seen in Table 1. Participants also chose from a list of educational backgrounds, but were allowed to choose all choices that applied to them, as seen in Table 1. For years taught, participants chose from a list with ranges of years taught (0-2, 3-5, 6-10, 11-15, 16-20, 21-25, 26 or more). These were initially coded as dummy variables, but were operationalized as the mean of each range to turn them into more meaningful continuous variables.

Most of the covariate measures also come directly from the teacher questionnaire. These include the amount of time to work with other teachers during the professional development, time to reflect during professional development, and support to implement what was learned in the professional development. All three of these variables came directly from the questionnaire, with a rank of 1 to 5, with 1 labeled as "Not at all" and 5 labeled as "To a great extent." The number of hours of professional development attended was listed in 11 categories on the questionnaire (0, 1-9, 10-19, 20-39, 40-59, 60-79, 80-99, 100-129, 130-159, 160-199, and 200 or greater). These were initially coded as dummy variables from 1 to 11, but were operationalized

as the mean of each range to change them into continuous variables with more meaning in the context of the research question.

The final three professional development variables, assistance to implement the professional development from LSC, participation in the LSC message boards, and increase in knowledge from professional development, are each means of multiple questions from the questionnaire. All of the original questions for these measures are on the same scale as the number of times participants did each activity (0, 1-2, 3-4, 5-6, and 7 or more). Assistance to implement the professional development is the average of four sources of assistance, coaching by LSC staff based on observations, LSC teacher leaders, LSC district staff, or LSC mathematicians or mathematics educators, with $\alpha = .7247$ with all four measures included. Participation with message boards was the average of three sources of participation, reading messages, posting messages, and discussion groups, but the $\alpha = .5107$ with all three sources and $\alpha = .6440$ with just reading messages and posting messages. Thus, participation is only the average of the two sources that leave the highest α, reading and posting on message boards. Perceived increase in knowledge was initially the average of three sources of knowledge, mathematics content knowledge, understanding of how children think/learn about mathematics, and ability to implement high-quality mathematics instructional materials, with $\alpha = .8887$. However, $\alpha = .8907$ by removing mathematics content knowledge, so perceived increase in knowledge is just the average of the two measures of teaching knowledge.

Table 3: Descriptive Statistics of Professional Development Variables by Sample and Original Data

	Sample Data						Original Data				
	M	SD	Min	Max	N		M	SD	Min	Max	N
Amount of time to work with other teachers	2.84	1.23	1	5	1,596		2.81	1.22	1	5	1,962
Level of time to reflect	2.76	1.19	1	5	1,596		2.73	1.18	1	5	1,957
Level of support to implement what was learned	3.42	1.15	1	5	1,596		3.39	1.15	1	5	1,952
Hours attended	93.78	67.04	5	200	1,596		62.07	69.32	0	200	2,843
Level of assistance to implement from LSC	1.43	1.62	0	7	1,596		1.40	1.60	0	7	1,908
Amount of participation in message boards	1.25	1.40	1	6	1,596		1.25	1.40	0	7	1,919
Perceived increase in knowledge	3.32	1.09	1	5	1,596		3.32	1.10	1	5	1,941

Note. $N = 3{,}064$ for the original data and $N = 1{,}596$ for the sample data.

Analysis

Given that the original analysis was concerned with how the teachers were able to implement the LSC curriculum materials in their classrooms, the possible covariates and control variables

were limited by the data collected in the teacher questionnaire. The covariates used were amount of time to work with other teachers during professional development, level of time to reflect during professional development, level of support to implement what was learned in professional development, hours of professional development attended, level of assistance to implement professional development from LSC, and amount of participation in LSC message boards. Research has shown collective participation (Desimone, 2009; Franke, Carpenter, Levi, & Fennema, 2001; Garet et al., 2001) and duration (Banilower, Heck, & Weiss, 2007; Garet et al., 2001; Heck et al., 2008) are both predictors of teachers' gains in knowledge from professional development. Other research has shown that aid to implement what is learned in professional development is related to teachers' long term use of what was learned in the professional development (Carpenter, Fennema, & Franke, 1996; Fennema et al., 1996; Franke et al., 2001). Participation in online forms of professional development has also been shown to be effective in helping teachers to gain knowledge (Boling & Martin, 2005; Dede, Breit, Ketelhut, McCloskey, & Whitehouse, 2005; Herrington, Herrington, Hoban, & Reid, 2009). The possible teacher control variables were gender, race, educational background, and number of years teaching. All were included, because it is likely that each will have an influence on how teachers view what they have learned from the professional development projects.

Results

The sample data are nested in 18 LSC professional development projects, so a hierarchical linear regression model was calculated. This model produced similar results to the multiple regression model, with the same professional development covariates being statistically significant predictors of perceived increase in knowledge from the professional development. In model 2, these variables include time to reflect on what was learned in the professional development, support to implement what was learned in the professional development, hours of professional development attended, assistance to implement what was learned in the professional development from LSC, and participation in LSC message boards; all were statistically significant at $p < .001$. Unlike the multiple regression however, the only statistically significant teacher control variable was gender ($t(1595) = -6.00; p < .001$).

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Table 4: Hierarchal Linear Model of Increase in Knowledge on Professional Development Variables and Teacher Control Variables

	Model 1	Model 2
	Perceived increase in knowledge	Perceived increase in knowledge
Time to work with other teachers	.0147	.0101
Time to reflect	.0958***	.1081***
Support to implement	.2067***	.1877***
Hours attended	.0047***	.0045***
Assistance to implement from LSC	.1112***	.1077***
Participation in message boards	.0683***	.0791***
Male		-.2719***
Hispanic		.2645
Indian		-.1649
Asian		-.1416
Black		.0763
Pacific Islander		-.8439
No Race Indicated		-.0513
Undergraduate Major		.0191
Undergraduate Minor		.0754
Graduate Major or Minor		.0109
Certification to Teach		.1726
Years Taught		-.0074
Constant	1.6898***	1.8256***
N	1596	1596
Note. t statistics in parentheses, $*** p < .001$, $** p < .01$, $* p < .05$. Reference group is white for race and no education in mathematics or mathematics education.		

Discussion

Both the multiple regression and the hierarchical linear model agree on the factors of the LSC professional development that related to the teachers' perceived increase in knowledge. The number of hours of professional development attended has the greatest standardized coefficient, so it has the greatest impact on the projected increase in knowledge. Specifically, for every one standard deviation increase in number of hours attended by a teacher, there is a projected .2889 standard deviation increase in knowledge. This agrees with the research findings that say that the duration of a professional development is one of its key features (Desimone, 2009; Garet et al., 2001; Heck et al., 2008). Another result that agrees with research is that the support and the assistance to implement the professional development is related to the increase in knowledge. Franke et al. (2001) found that the teachers felt the support of the professional development team was a critical factor in their ability to sustain what they learned in the professional development.

Finally, participation in the message board was also a statistically significant predictor of the teachers' increase in knowledge, which agrees with research that online professional development can help teachers increase their knowledge (Boling & Martin, 2005; Dede et al., 2005; Herrington et al., 2009).

One result that does not agree with research is about the time to work with other teachers. Research shows that collective participation is a key feature of professional development (Desimone, 2009) with a positive relationship to increased knowledge (Garet et al., 2001). However, the multiple regression found working with other teachers to have a negative relationship that was not a statistically significant predictor of increase in knowledge.

Limitations

These results are based on self-reported survey data from the participants about their views on the professional development project and what they learned from the professional development project. However, Desimone (2009) argues that surveys are a reliable data source for behavior-based constructs about frequencies of events, such as teachers' experiences in professional development and experiences implementing the professional development. This data is a mix of behavior-based questions and evaluative questions, so using a survey may not be the most reliable source of data collection. Another limitation is that the teachers are rating their own perceived increase in knowledge, rather than using a pretest and posttest of knowledge to quantify how much teachers learned. This makes it difficult to know how much the teachers actually learned from attending the professional development.

Next Steps

This analysis focused on teacher knowledge, but not on how teacher knowledge affects teaching practices or student achievement. Research has shown that teacher knowledge has an impact on both practice in the classroom and on students' achievement (Ball, Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Kennedy, 1999). Although data is not available about student achievement for the LSC projects, the teacher questionnaire included questions about teaching practice. Thus, a next step would be to analyze whether the change in knowledge predicts teaching practice, as was found in other research on professional development (Desimone, 2009; Garet et al., 2001; Heck et al., 2008).

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