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THE RELATIVE INFLUENCE OF FORMAL LEARNING OPPORTUNITIES VERSUS INIDICATORS OF PROFESSIONAL COMMUNITY ON CHANGES IN SCIENCE TEACHING IN URBAN SCHOOLS

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Abstract

Previous research has shown that professional communities have the potential to be a powerful lever for continuous improvement in school settings. This research seeks to extend previous research by investigating the indicators of professional community that influence science teaching practice. This study took place in a network of urban neighborhood high schools, where low student achievement and high teacher turnover present barriers to professional community. Science teachers were surveyed on the extent to which they participated in a variety of formal learning opportunities and engaged in collaborative practices that are indicative of professional community over the course of a school year. The teachers also indicated the extent to which they changed their teaching practices during the same time frame. The results indicate that teachers engaged in a variety of collaborative activities such as advice seeking and collaborative discussions about curricula and student work. These conversations were associated with changes in teaching practice.

Keywords: professional community, professional development, science teaching, high schools

The existence of strong professional community among urban teachers can play a significant role in reducing teacher turnover (Allensworth, Ponisciak, & Mazzeo, 2009), improving teacher content knowledge (Fulton, Doer, & Britton, 2010), and sustaining teaching improvements gained through professional development (Parise & Spillane, 2010). In addition, schools with a strong professional community focused on curriculum alignment significantly increase the probability of sustaining long-term growth in student learning (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010, p. 116). The development of professional community requires shared visions, ample time for collaboration, stable settings, and the development of teacher leadership capacity (Fulton & Britton, 2011; Panizzon, Barnes, & Pegg, 2007; Roehrig, Kruse, & Kern, 2007). However, the limited experience and high turnover of teachers in low-achieving, urban schools creates unstable settings that impede the development of these key ingredients of successful professional community (Allensworth et al., 2009; McLaughlin & Talbert, 2006). Much of the literature base on professional community has been focused on research projects that intentionally supported the development of professional community in

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schools (Fulton et al., 2010). We know little about the extent and impact of professional community in urban settings that are not part of professional development program.

Conceptual Framework

"*We need to know more about STEM PLCs that are naturally occurring in the field.*"
(Fulton et al., 2010, p. 9)

This work is anchored in the literature on professional community. Given the breadth of conceptual frameworks in the literature on professional community, I do not seek to develop a operating definition of what is and what is not professional community. My approach is consistent with several recent reviews of the literature on professional community that have attempted to synthesize the breadth of published professional community frameworks in general (Bolam et al., 2005; Vangrieken, Dochy, Raes, & Kyndt, 2015) and in science specifically (Fulton et al., 2010). Given the diversity of approaches that schools have taken to form professional community supported by researchers, none of the reviews were able to synthesize a coherent framework. The terminology for professional community comes in many forms, such as, professional learning community, lesson study, communities of practice, teams, and groups (Vangrieken et al., 2015). Regardless of the specific terminology or structure, the reviews have identified some common elements of professional community (Bolam et al., 2005; Fulton et al., 2010). Teachers develop shared goals and collective responsibility for connecting teaching to student learning. There is a stance of inquiry through group norms, expectations, and processes, which leads to increased levels of informal collaboration. There is strong leadership outside of the professional community that supports and holds the community responsible. This leadership is both internal to the school (e.g., the principal) and, as most often characterized in the literature, leadership also comes from outside of the school (e.g., university researchers).

By way of example, I present two representative initiatives that provided external support for the development of professional community among a collection of schools. In the first example, the Getting Results project worked with nine low-performing elementary schools in Los Angeles (Saunders, Goldenberg, & Gallimore, 2009). In the initial two years of the project, external researchers worked only with the principals at each school, who in turn attempted to support the development of grade level teams. However, the researchers realized that grade level teams needed direct support, so in the final three years of the project, the grade level teams received direct support from the external researchers (McDougall, Saunders, & Goldenberg, 2007).

The grade level teams followed a series of protocols to engage in an inquiry cycle about teaching and learning. Teachers first identified a common student need to work on together and formulated a clear objective through analysis of representative student work. The team then identified a promising instructional intervention to address students' needs and collaboratively planned the intervention. Each team member then implemented the intervention. The team analyzed the resulting student work to see if the objective was met and then determined whether to the repeat cycle or move on to another area of need.

Over the course of the final three years of support, the standardized achievement of students in Getting Results schools moved from well below the district average to slightly above the district average (Saunders et al., 2009). In addition, Getting Results schools outperformed a matched set of low-performing schools that implemented a district-mandated school reform program. The project leaders cite five key factors for the success of Getting Results: (a) goals

were set, shared, and articulated explicitly by the school community; (b) there were meaningful indicators that measured progress toward goal attainment; (c) teachers received assistance from capable others both within and outside the school; (d) school leadership both supported and pressured goal attainment; and (e) there was a dedicated time and space to meet on a regular basis.

The second example comes from the Bay Area School Reform Collaborative (BASRC) (McLaughlin & Talbert, 2006). BASRC supported 86 Leadership Schools in its first five years. These schools were accepted into the program through an application process and remained in the program through an annual portfolio review. BASRC provided supplemental funding to Leadership Schools. The primary use of the supplemental funds was to provide release time for a teacher at the school to serve as the reform coordinator. The remaining funds were used at the discretion of the schools. To provide support to the schools, BASRC developed tools and resources as well as hosted workdays and affinity groups.

Successful Leadership Schools engaged in regular cycles of inquiry, similar to Getting Results. However, in the case of BASRC, schools focused specifically on standardized achievement data as the lens for defining student needs. In addition, BASRC allowed schools to develop their own approaches to forming professional community and accomplishing the reform goals. School teams developed questions, collected and analyzed data, and took action. Through the process of inquiry, teachers at Leadership Schools developed shared language, fostered collective responsibility, became adept at managing data, were strategic about use of outside resources, and were better able to manage external pressures.

This distributed approach resulted in tremendous variability in approaches and accordingly variability in success at fostering the development of professional community (McLaughlin & Talbert, 2006). An MRDC outside evaluation of the overall set of Leadership Schools showed no main effect of BASRC on student achievement (Porter, Snipes, & Eisberg, 2006). However, the overall evaluation did not take into account the spectrum of implementation quality. Some Leadership Schools remained stagnant with weak professional community. Other schools developed to an intermediate stage, where data was used to identify problems, but the inquiry cycle did not influence the way in which solutions were identified, implemented and evaluated. Advanced Leadership Schools were able to undertake the full inquiry cycle of using data to identify needs and then implementing strategies to address those needs. These advanced schools did show evidence of improvement in student achievement (McLaughlin, Talbert, & et. al., 2002).

The challenges of fostering professional community faced by these two example projects are representative of the challenges commonly described in the literature. At the same time, these two examples are representative of the literature for the successes that can be achieved at impacting student learning when the challenges to fostering professional community are overcome with the help of external experts. However, these successes can be tenuous. "School-based teacher learning communities often fall apart in the face of local shifts in leadership and changing political tastes." (McLaughlin & Talbert, 2006, p. 114) Shifts in local leadership and changing political tastes are characteristic of schools in urban settings. In addition, schools in the poorest urban neighborhoods tend to have the lowest levels of external social capital that can provide outside experts for facilitating the development of professional community (Bryk et al., 2010). Therefore, to better understand the potential of fostering professional community in urban settings, it is important to investigate contexts with shifting leadership and lack of outside facilitators to support the development of professional community.

By way of contrast to what is typically reported in the literature on professional community, I focus in this study on a network of low-income, urban high schools that are not receiving external support. Within that context, it is not feasible to measure the prevalence of specific elements of professional community, such as certain types of meetings or use of certain types of protocols. Rather, in this work I seek to study the impact of professional community by measuring the levels of collaborative activity as an indicator of the presence of professional community, in whatever professional community support structure the school is using. These indicators are the frequency of collaborative discussion, peer observation, and advice seeking. I examine the prevalence of these indicators of professional community relative to the prevalence of formal learning opportunities and the relative impact of these professional learning opportunities on changes in teaching practice.

Formal Learning Opportunities

This work is also anchored in literature on teacher professional development. Some evidence of the features that support professional growth has been identified in prior research. In a recent review of professional development research, Desimone and Garet (2015) present a conceptual framework highlighting key features for designing professional development to positively impact teacher knowledge and changes in teaching. One of the professional development features highlighted in their review is the extent to which the professional development activities focus on active learning, which means engaging participants as active adult learners. The characteristics of active engagement in professional development include planning instruction and giving professional presentations. In addition, active engagement in professional development includes characteristics often associated with professional community—peer observation and collaborative discussion of student work. The Desimone and Garet conceptual framework for professional development aggregates the prevalence of these four characteristics of active engagement into a single active learning scale. This active learning scale aggregates both individual and group activities. In addition, this active learning scale does not make a distinction between teachers collaborating with colleagues in their school or teachers collaborating with peers from other schools participating in the professional development.

In a national study of professional development features, Garet, Porter, Desimone, Birman, and Yoon (2001) found that the extent to which professional development included active learning significantly predicted improvements in teacher knowledge, but did not have a direct effect on changes in teaching practice. To be successful at shifting teacher practices beyond changes in routine instructional strategies, professional development must be coherent with teachers' school context, be long in duration, and encourage collective participation of all school staff (Desimone & Garet, 2015). Desimone and Garet (2015) also highlight the challenges of conducting research on professional development in urban settings where there is minimal documentation of professional development offerings and participation. In addition, frequent staff turnover makes it difficult for schools to maintain coherence and support teachers in applying what is learned from professional development.

Parise and Spillane (2010) extended the findings of Garet et al. (2001) by investigating how changes in teaching practice are differentially influenced by the indicators of professional community that are related to the Desimone and Garet (2015) active learning scale. Parise and Spillane (2010) labeled these indicators of professional community as on-the-job learning opportunities (i.e., peer observation, collaborative discussion, and advice seeking). They compared these indicators of professional community to formal learning opportunities, including

professional development, coursework, and network participation. Their study investigated these indicators for elementary math and English teaching in an urban setting, but not for science teachers. Of the various types of formal learning opportunities, content-specific professional development significantly predicted changes in teaching practices, which is consistent with Garet et al. (2001). In contrast to Garet et al. (2001), Parise and Spillane (2010) found that a subset of the indicators of professional community directly predicted changes in teaching practices, specifically collaborative discussion and advice seeking. While the impact of professional learning opportunities on student learning is not a focus of this investigation, similar research has shown that these self-reported changes in teaching practice are predictive of improvements in student learning in English and math (Supovitz, Sirinides, & May, 2010).

In this study, I seek to extend the findings from Parise and Spillane (2010) into the discipline of high school science. Since there was not any outside support for these schools, this research will begin to address Fulton et al. (2010)'s call for more research on indicators of science professional communities that are "naturally occurring in the field." How prevalent are the indicators of professional community in the absence of a specific program to support professional community? To what extent do the presence of indicators of professional community predict changes in teaching practice among urban high school science teachers? What is the relative impact of the prevalence of formal learning opportunities vs. indicators of professional community on changes in teaching practice?

In this research project, I investigate the characteristics of formal learning opportunities and indicators of professional community that predict self-reported changes in science teaching for 15 high school science departments in the same high school network in Chicago. With the Chicago Public Schools' (CPS) experiencing the kinds of "shifting leadership" that creates challenges for professional community as described by McLaughlin and Talbert (2006), the recent period of rapid turnover in superintendents and subsequent policy ambiguity (Kennedy, 2015) makes the district a worthwhile subject of study for how professional learning opportunities influence teaching practice in urban schools that are not receiving external support. This setting contrasts with previous research that has examined these questions in the context of ongoing external professional development and support for the development of professional community (Fulton et al., 2010; McLaughlin & Talbert, 2006). At the time of this study, there had not been a coherent science program of external teacher support in these high schools for several years.

Methods

During the months of May and early June 2013, I attended a science department meeting in fifteen of the sixteen schools in one out of a half dozen high school networks in Chicago to administer an online version of the *School Staff Questionnaire* used in Parise and Spillane (2010). During the 2012-13 school year, there were 102 science teachers across the fifteen schools in the network, 22 special education science teachers, and 20 special education teachers assigned to teach at least one science class out of multiple content area assignments. After inviting teachers to participate in the research at the science department meeting, participants had the opportunity to indicate their willingness to participate by signing an informed consent form. A total of 94 science teachers (92%), 15 special education science teachers (68%), and 3 special education teachers assigned to multiple content areas (15%) agreed to participate and completed the online survey during their science department meeting (n=112 teachers). The survey sample includes almost all of the science teachers and a majority of the special education science teachers in the

fifteen high schools in the network. There is low representation of special education teachers assigned to multiple content areas, as it is difficult for those teachers to attend the weekly department meetings for all of their content area assignments.

Measures

The survey instrument comes from previous research on teachers' professional learning opportunities (Goldring, Huff, Pareja, & Spillane, 2008; Goldring, Spillane, Huff, Barnes, & Supovitz, 2006; Supovitz et al., 2010). Questionnaire items are primarily closed-ended and ask about the teachers' work in and out of the classroom. In one open-ended question, respondents are also asked to describe their in-school social networks by listing the names of people from whom they seek advice about science. The following sections detail the dependent variable of changes in teaching practice, the independent variables related to the types of professional learning opportunities, and the control variables related to teacher demographics. The survey contained twenty-six questions, which took about 15 minutes to complete during the departmental meeting.

Changes in science teaching practices scale (dependent variable). The dependent measure is a scale comprised of eight questions about the extent to which teachers changed their science teaching practice in the past year. On a 7-point scale ranging from *not at all* to *a great deal,* participants were asked to indicate how much they changed their science teaching during the past year for the following eight aspects of teaching: (1) student assessment, (2) student grouping, (3) materials used, (4) topics covered, (5) teaching methods used, (6) kinds of work students do, (7) kinds of questions asked, and (8) understanding the needs of individual students in their class. The items were averaged to create the changes in science teaching practices variable, which served as the dependent variable for this study. The alpha reliability of the changes in science teaching practices variable was 0.93.

Since these questions are Likert self reports, there is no information to characterize or validate the actual changes that teachers made to their teaching practice. However, Supovitz et al. (2010) have shown that this changes in teaching practice scale can be a useful indicator for positive changes in teaching practice. Their research indicated that this self-report changes in teaching practice scale is a strong predictor of growth in student learning outcomes. In addition, both Supovitz et al. (2010) and Parise and Spillane (2010) have shown that this changes in teaching practice scale can be impacted by the prevalence of different types of professional learning opportunities. I seek to explore that same relationship between the prevalence of professional learning opportunities and self-reported changes in science teaching practice.

Formal professional learning opportunities (independent variables). There were three questions about formal professional learning opportunities, including science professional development, science courses in the past year, and outside network participation. Given that there was not a uniform program of formal professional learning opportunities for this network of schools and the general lack of documentation of formal learning opportunities in urban settings (Desimone & Garet, 2015), it was not feasible to attempt to characterize the nature of the professional learning opportunities. Instead, the survey documents the frequency of teachers' self-reported participation in three types of formal learning opportunities. The alpha reliability of the formal professional learning opportunities scale was 0.30, which indicates that each of the questions addresses different components of formal professional learning. Therefore, each question will be used separately as an independent variable.

Science professional development. On a 4-point scale ranging from *none* to *8+ sessions,*

participants were asked to indicate the number of professional development sessions they participated in during the past year.

Science courses. On a 5-point scale ranging from *none* to *4+ classes,* participants were asked to indicate the number of undergraduate or graduate level courses they had taken in science or science teaching in the past year.

Outside network participation. On a 6-point scale ranging from *never* to *10 or more times,* respondents were asked to indicate how often they participated in a network with other teachers outside of their school in the past year.

Indicators of professional community (independent variables). There were ten questions about the prevalence of indicators of professional community. These questions were organized by three categories of indicators: collaborative discussion, peer observation, and advice seeking.

Collaborative discussion and review of student work. The collaborative discussion dimension contains seven questions that measure the self-reported frequency with which teachers' engage in conversation with colleagues regarding teaching and learning. The scale does not capture the nature or quality of the conversation, but rather the topics of conversation. On a 5-point scale ranging from *never* to *more than 2 days/week,* participants are asked questions regarding the frequency of their conversations with colleagues around issues of teaching and learning: (a) what helps students learn the best, (b) development of new curriculum, (c) the goals of this school, (d) managing classroom behavior, (e) science instruction, and (f) content or performance standards in science. On the same 5-point scale, respondents are also asked to indicate how often they had engaged in collaborative review of student work. The alpha reliability of the collaborative discussion scale as a whole was 0.87.

Peer observation and feedback. There were three questions about the frequency with which teachers engage in peer review and feedback. On a 5-point scale ranging from *never* to *more than 2 days/week,* participants are asked to indicate how often they participated in three different observation and feedback activities around instruction: (a) how often the teacher observed someone else, (b) how often someone else observed the teacher, and (c) how often the teacher received feedback based on someone's observation. The scale does not capture the nature or quality of the peer observation, but rather the frequency of peer observation and feedback. The alpha reliability of the peer observation and feedback scale was 0.80.

Science advice seeking. There was one question related to science advice seeking. Teachers were asked, "To whom do you turn for advice or information about science instruction?" Respondents could list up to ten different individuals who served as sources of advice. As an indicator of strength of the relationship with each advice giver, teachers were also asked to indicate how often they turned to each source for advice, ranging from *yearly* to *daily.* The science advice seeking measure is created by totaling the frequency with which advice was sought from all sources listed.

Teacher characteristics (control variables). There were five questions about individual teacher characteristics, which were included as control variables in my analyses, including age, number of years as a teacher, number of years teaching at the current school, gender, and race.

Population

The teachers in this study come from 15 of 16 schools in a particular network of schools in Chicago. While there was no external support for specific professional community, schools generally provided a time and space for teachers who taught the same course to meet as a course

team on a weekly basis. These weekly course team meetings provided opportunities for teachers to collaboratively plan and reflect on instruction, but there was no explicit guidance or accountability on how teachers were to use that time. The lack of guidance and accountability suggests that there was likely great variability in the extent to which teachers took advantage of those opportunities to collaborate. Moreover, in smaller schools, there was typically only one teacher for a given course, so there was no opportunity to collaborate as a course team. This research did not directly measure what occurred during these meetings, but rather provides measures of the frequency with which teachers engaged in the kinds of collaborative discussions that would be occurring in high functioning course teams.

A total of 112 teachers responded to the survey. Over half of the teachers identified as Caucasian (56%), around one-fourth identified as African American (26%), about one-tenth identified as Hispanic (12%). The remaining teachers identified as Asian (7%) or other (6%). Almost two-thirds of the teachers were female (64%). The distribution of overall teaching experience is somewhat uniform (see third column of Table 1). The average number of years of teaching was just over 12 years. However, the average number of years teaching at the current school was around 7.5 and the distribution was skewed toward the lower end. Almost half of the teachers were at their school for five years or less. This discrepancy between overall teaching experience and experience at the current school suggests that the population reflects the high turnover rate within CPS as a whole (Allensworth et al., 2009).

	At School	Total
1-5 yrs	55	31
6-10 yrs	23	18
11-15 yrs	16	26
16-20 yrs	9	18
> 20	5	18

Table 1: Years of Teaching Experience

Results

Descriptive Results

Table 2 presents the descriptive statistics for the primary dependent and independent variables included in this study. The number of participants that responded to each question, sample means, and standard deviations are listed. Also, the scale label for the average value is listed. The dependent variable—changes in science teaching—indicates that, on average, teachers were slightly above the midpoint on the scale, which suggests that teachers implemented a fair amount of changes in their classroom practice and there was substantial teacher-level variation in the amount of change implemented. In terms of formal professional learning opportunities, teachers on average participated in 3-7 workshops during the school year and participated in a network with science teachers outside of their school a couple of times per year. The average rating for taking a graduate class in science or science teaching in the last school year was a little less than 1. During the 2012-13 school year, CPS provided tuition subsidies for math and science teachers to take graduate courses in science and math.

Variable	Label Associated with Average Value	Mean	SD	N
Dependent Variable				
Changes in science teaching		4.3	1.4	112
Formal Learning Opportunities				
Science professional development	3-7 sessions	2.7	0.9	110
Outside network participation	1-2 times	2.2	0.9	110
Science courses this year	1 class	0.7	1.3	110
Indicators of Professional Community				
Science Advice Seeking:		*12.2*	*8.0*	*109*
Number of Advisors	5 Advisors	4.6	2.9	109
Average Frequency of Advice	Weekly	2.9	0.7	98
Conversations about:	1-2 days/wk	*3.5*	*0.8*	*112*
What helps students learn best	1-2 days/wk	3.9	1.0	110
Your science instruction	1-2 days/wk	3.9	1.1	110
Content or performance standards	1-2 days/wk	3.7	1.0	109
Managing classroom behavior	1-2 days/wk	3.6	1.2	109
The goals of this school	Few times/month	3.3	1.1	109
Development of new curriculum	Few times/month	3.3	1.1	110
Review your students' work	Few times/month	2.5	1.0	110
Peer Observation and Feedback:	*Few times/year*	*2.2*	*1.0*	*112*
Observe another classroom teacher teach	Few times/month	2.5	1.4	112
Another classroom teacher observe you teach	Few times/year	2.3	1.2	110
Another classroom teacher give you feedback after observing you teach	Few times/year	1.9	1.0	111

Table 2: Descriptive statistics for the dependent and independent variables

Teachers participated in collaborative activities more often than formal professional learning opportunities. Advice seeking was the most frequent behavior. Teachers on average sought advice weekly from about five colleagues. Recall that the overall advice seeking metric combines the number of advisors and the frequency of seeking advice. In addition to advice seeking, teachers engaged in collaborative conversations with their colleagues on average a couple of times per week. They more frequently discussed how students learn best, science instruction, classroom behavior, and performance standards—a couple of times per week. A little less frequently, teachers discussed the goals of the school, developing new curricula, and student work—a few times per month. Teachers engaged in peer observation and feedback a few times per year. They more frequently observed other teachers (few times per month) than they themselves were observed by other teachers and received feedback (few times per year).

Regression Results

As indicated above, this research seeks to extend the findings of Parise and Spillane (2010) to the setting of high school science. Therefore, I followed their analytic strategy for modeling the impact of formal learning opportunities and indicators of professional community on changes in teaching practices. To analyze the extent to which changes in teaching practice were associated with formal learning opportunities and indicators of professional community, I developed three multiple regression models. The first model examined the influence of formal learning opportunities on changes in teaching practice. The second model examined the influence of the indicators of professional community of changes in teacher practice. The third model examined the influence of both formal learning opportunities and indicators of professional community on changes in teaching practice. For each of the models, the teacher demographic variables were used as controls. Race and gender were included in all three of the models, but they were not statistically significant in any of the models. Age, total years of teaching experience, and years of experience at the current school were all highly correlated and showed evidence of multicollinearity. Thus, when more than one of these factors was included in the models, none of the factors were statistically significant, even though individually each factor inversely, statistically predicts changes in teaching practices. In other words, the older or more experienced teachers made fewer changes to their teaching practice. In order to select which of the three variables to include in the models, I examined the amount of variance in changes in teaching practice that each factor independently explained. Experience at the same school explained 12%, total experience explained 6%, and age explained 8%. Therefore, experience at the same school was selected as the indicator for experience across all three models.

Table 3 shows the results of these multiple regression analyses. The cell values are the standardized betas. The statistically significant variables are bolded. All three models were statistically significant. The first model examined the effect of formal learning opportunities on changes in teaching practice ($F(8,89) = 3.69$; $p < 0.01$; $R^2 = 25\%$). The model included the frequency of participation in the three types of formal learning opportunities as well as the demographic variables. Of the three formal learning opportunities, the only characteristic that was statistically significant was the number of science or science teaching classes teachers completed in the current school year. About 25% of the teachers in the sample indicated that they had taken one or more classes. It is possible that several of these teachers took advantage of tuition subsidies and stipends that the school district provided for the 2012-13 school year to encourage science and math teachers to deepen their content knowledge through university coursework.

The second model examined the effect of the indicators of professional community on changes in teaching practice ($F(9,87) = 7.69$; $p < 0.001$; $R^2 = 44\%$). In analyzing the indicators of professional community, I sought to unpack the characteristics of teachers' conversations that were associated with changes in teaching practice. I first analyzed each of the topics of conversation separately. I then included in the final model those conversational topics that were statistically significant. The statistically significant indicators of professional community are frequency of conversations about curriculum, collaborative review of student work, and science advice seeking. The frequency of peer observation and feedback was not a statistically significant predictor of changes in teaching practice. It is worth noting that the indicators of professional community model explained almost two times as much of the variance as the formal learning opportunities model.

The third model examined the combined effects of formal learning opportunities and

indicators of professional community on changes in teaching practice ($F(12,78) = 6.29$; $p < 0.001$; $R^2 = 49\%$). Adding the formal learning opportunities variables to the indicators of professional community model only adds 5% additional explanation of variance in the Full Model. However, none of the formal professional learning variables are statistically significant in the full model. The length of time that a teacher had been at a particular school is statistically significant in all three models. It is associated with fewer changes the teacher made to his/her science teaching practice.

	Changes in Science Teaching Practice		
Independent Variable	Formal Opportunities Only	Indicators of Professional Community Only	Full Model
Formal Professional Learning			
Science Professional Development	0.12		0.08
Science Courses (School Year)	**0.28****		0.15
Outside Network Participation	0.04		-0.11
Professional Community			
Conversations about:			
Student Work		**0.30****	**0.32****
Curriculum		**0.29****	**0.24****
Science Advice Seeking		**0.25****	**0.27***
Peer Observation and Feedback		-0.02	-0.03
Teacher Controls			
Years Teaching at Current School	**-0.20***	**-0.20***	**-0.21***
Gender, Race	NS	NS	NS
R-square	25%	44%	49%
Observations	98	97	91

Significance Levels: 0.05 = *; 0.01 = **; NS = not significant

Table 3: Results of Multiple Regression

Discussion and Conclusion

Previous research has shown that professional communities have the potential to be a powerful lever for continuous improvement in school settings. However, these previous research studies have taken place in the context of ongoing professional development programs and external support for professional community. Garet et al. (2001) found that professional development with active learning components (i.e., actively engaging adult participants with specific activity structures) increased teacher content knowledge of science, but did not influence teaching practices. Their research results, however, are confounded by the fact that their active learning dimension aggregated several of the indicators of professional community. The current research has shown that these indicators have differential influences on changes in teaching practices. The fact that Garet et al. (2001) did not find an influence of active learning on teaching practice may be due to aggregating the effects of different indicators into one scale. Parise and Spillane (2010) found that both formal learning opportunities and indicators of professional community have a significant influence on changes in teaching practice in English and math. In

contrast, this research found that the influence of the indicators of professional community explained the vast majority of the variance in changes in teaching practice. None of the formal opportunities were statistically significant within the model that included indicators of professional community. I do not believe that these findings suggest that formal learning opportunities are unimportant. It is important to recall that there was not any coordinated science professional development intervention occurring. These findings might suggest that in the absence of a coordinated formal professional development program, the resulting haphazard professional development lacks coherence as defined by Desimone and Garet (2015) and therefore, has limited influence on changes in teaching practices. What this current research does suggest is that conversations about curriculum and student work are commonly occurring in urban high school settings without external support despite the changing district leadership and policy ambiguity in the district. These conversations about curricula and student work have a significant influence on changes in teaching practice. Science educators who are supporting implementation of science curricula in urban settings would be well advised to consider how to support these ongoing conversations about their curricula and resulting student work products as a way to increase the probability that the intervention will sustain after the professional development component comes to end.

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