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Janine Remillard
University of Pennsylvania

Cecile Sam

Jordan D'Olier
University of Pennsylvania

Hayden Lyons
University of Pennsylvania

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School-Based Structures That Support Teacher Use of Learning Trajectory Frameworks

Abstract

The OGAP intervention incorporates two approaches to mathematics instruction that are well supported by research, but have not been uniformly adopted in U.S. schools: The first is ongoing formative assessment by teachers to tailor instruction to student needs (Black & Wiliam, 1998); the second is the use of learning trajectories to specify conceptual pathways for student development within specific domains (Daro et al., 2011; Sztajn et al., 2012). Implementing OGAP in schools involves a great deal of learning on the part of teachers and school leaders. It also involves embracing a fundamental shift in how one thinks about learning and designing instruction.

The OGAP intervention provided grade 3-5 teachers with tools to support learning-trajectory formative assessment practices (described in other papers) and professional development (week-long summer training and several additional training days during the academic year). We also included a site-based approach to increase understanding and capacity across all participating teachers. Each school was asked to hold a bimonthly Professional Learning Community (PLC) with the primary purpose of collaboratively analyzing student work, using learning trajectory frameworks and determining appropriate instructional responses. PLCs were envisioned as a primary structure to support use of OGAP in the schools throughout the year. They were also intended to situate the use of OGAP tools and routines in each school and normalize opportunities for discourse about student thinking among teachers (Putnam & Borko, 2000). By providing teachers with ongoing and consistent opportunities to discuss their own students' work and use the OGAP frameworks to make instructional decisions, we anticipated they could potentially deepen teachers' understanding of OGAP and their own students' thinking. In this paper, we examine five PLCs in the OGAP project in order to consider the extent to which this potential was realized.

Keywords

OGAP, NSF, Ongoing Assessment

Disciplines

Curriculum and Instruction | Educational Assessment, Evaluation, and Research | Educational Methods

Comments

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School-Based Structures that Support Teacher Uptake of OGAP Routines and Practices¹

Janine Remillard, Cecile Sam,* Jordan D'Olier, and Hayden Lyons
Consortium for Policy Research in Education
Graduate School of Education, University of Pennsylvania
*Now at Rowan University

The Purpose of OGAP PLCs

The OGAP intervention incorporates two approaches to mathematics instruction that are well supported by research, but have not been uniformly adopted in U.S. schools: The first is ongoing formative assessment by teachers to tailor instruction to student needs (Black & Wiliam, 1998); the second is the use of learning trajectories to specify conceptual pathways for student development within specific domains (Daro et al., 2011; Sztajn et al., 2012). Implementing OGAP in schools involves a great deal of learning on the part of teachers and school leaders. It also involves embracing a fundamental shift in how one thinks about learning and designing instruction.

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PLCs as Sites for Learning

The use of communities of practice (Wenger, 1998) as sites for teacher learning has been well established in the field of education reform (Grossman, Wineburg, Woolworth, 2001) and mathematics education in particular (Cobb, McClain, Lamberg, and Dean, 2003; Franke & Kazemi, 2004; Kazemi, 2008). Both Wenger and Cobb and colleagues suggest that communities of practice are productive sites for learning because of their mid-level position between two elements of schools that are frequent targets of reform: school structures or organizations and teachers' instructional practices. Establishing PLCs involves a moderate shift in the school's organization and provides a space for teachers to collectively discuss teaching practice. Over time, by bringing instructional practice into a shared space, the work that happens within PLCs *can* become generative, having an impact on teaching practice and the school as an organization (Boreham & Morgan, 2004).

Arguably, some schools and school systems are better prepared to take on organizational change than others. School systems that have coherent curricula, shared instructional approaches, structures that empower visionary leaders to guide change, for example, are more likely to undergo system-level change (Snipes, Doolittle, & Herlihy, 2002). Gutiérrez (1996) uses the term "organized for advancement" to describe high schools that have strong professional communities aimed at advancing student learning. The urban school systems in the OGAP study (one large school district, a mid-sized district, and several charter schools) were not in the position to take on organizational change, especially in mathematics teaching and learning, given other pressing challenges, including size, extreme financial constraints, limited investment in mathematics, competing commitments, and leadership turnover. The fact that they agreed to participate in the study, however, suggests an interest in moving this direction.

A number of studies have documented the development of school-based communities of practice and their impact on teaching and organizational learning (Kazemi, 2008). Despite their promise, it is well understood that developing the community norms and trust required for productive PLCs to gain traction in schools is often challenging and requires an investment of time and support. The OGAP project faced the challenge of establishing PLCs in 30 schools through a limited intervention. To be fair, we did not expect OGAP PLCs to reach the quality described in the research literature in such a short period of time. Our theory of action, however, was that those PLCs that could take up OGAP tools and routines could begin to foster the types of learning needed to fully embrace learning-trajectory focused formative assessment practices. Our qualitative analysis of active PLCs provides us with the opportunity to test this theory and understand the factors that support and constrain learning in school-based PLCs.

OGAP PLCs as a Site for Learning

PLCs were led by teacher leaders, who had been identified by the school principal and were provided with an additional day of training each year. Principals in the study agreed to protect time for PLCs to meet on a regular basis during the school day. The project team recognized that the intended approach to PLCs was likely to be unfamiliar to many teachers and principals in the study. During the first year of implementation, the team was not surprised to find uneven implementation of PLCs in treatment schools. In the second year, each school was assigned an OGAP coach, who visited the school monthly to support teacher leaders and principals to establish PLCs and focus them on OGAP tools and routines.

In this paper, we present qualitative analysis of five active PLCs in the group of 30 treatment schools to understand whether and how they support the implementation of OGAP routines and practices. Our specific research questions are:

1. How would we characterize the range and variation of the five PLCs in terms of a) frequency and consistency and b) uptake of OGAP tools, routines, and practices?
2. To what extent do these PLCs provide teachers an opportunity to learn about and take up OGAP tools, routines, and practices?
3. What factors influence the differences found among the five PLCs?

Analytical Framework

Our analysis of the OGAP PLCs focused on how teachers prepared for PLCs and the nature of the discourse during them. We were particularly interested in the use of OGAP tools and routines and evidence of shifts toward a stance of collaborative inquiry around one's teaching. We drew on Wenger's (1998) description of three dimensions of communities of practice and Cobb, McClain, Lamberg, and Dean's (2003) application of these dimensions to schools and districts to develop a conceptual framework to identify quality of interactions during the PLCs. Wenger's dimensions of communities of practice include: a) shared purpose or enterprise, b) norms of mutual engagement, and c) well-honed repertoire of ways of reasoning with tools and artifacts. Cobb et al argue, and others (e.g., Kazemi, 2008) argue that the focus of these dimensions must be on the instructional goals of the reform. For our purposes, we were interested in whether the shared purposes, norms, and repertoires established in the PLCs fostered understanding of and use of OGAP practices.

Methods

The Selection of PLCs

In the findings section, we provide a summary of the PLC activity in all 30 schools. According to regular coach reports, nine schools had at least one active PLC. The five PLCs analyzed in this

paper were selected because they agreed to have a researcher visit over several weeks and to participate in interviews.

Data sources

A researcher visited each PLC 2-4 times, observed the interactions, audio recorded, and took field notes. Using a semi-structured protocol, we interviewed each teacher leader before visiting the first PLC and again after the observations had been completed. We also interviewed up to two teachers who participated in each PLC. All interviews were audio-recorded and transcribed.

Research sites and Teacher Leaders

The five PLCs studied were located at three OGAP schools, Hawthorn, Maple, and Larchwood². Demographic details of each school are included in Table 1. We have used approximate numbers and percentages to mask the schools’ identities. A brief description of the PLCs and Teacher Leaders follows.

Table 1: School Demographic Information

School Name	Approx. Enrollment	Percentage students identified as. . .						
		African Am	Asian	Latinx	White	Other	Special Education	Economic Disadvan.
Hawthorn	400	10	2	15	60	13	25	100
Maple	1000+	35	18	25	10	12	10	100
Larchwood	800	10	20	8	50	12	10	90

Hawthorn Elementary School had two PLCs, one for grade grades 4 and 5, inclusive of two special education teachers (Hawthorn A) and one for grade 3 teachers (Hawthorn B). Both PLCs were led by the same teacher leader (TL-D.). The school principal, Mr. H. was supportive of OGAP and adjusted the prep schedule so that teachers were free to attend their PLC meetings every other week. The Hawthorn PLCs were scheduled to meet on alternate Mondays from 2:30-3:05.

Maple Elementary school had two 5th grade PLCs that met concurrently in the same 5th grade classroom from 8:35-9:25. Each was led by different teacher leaders. Maple A was led by TL-M and included a mix of specialists and classroom teachers. Maple B was led by TL-S and was made up of classroom teachers. The meetings occurred once a month during a scheduled teacher prep time. The principal, Mr. M, was very supportive of OGAP and included PLC times in the teacher prep schedule. He also visited each PLC session we observed during the last 5-10 minutes.

² All school and teacher names are pseudonyms.

Larchwood Elementary School had three PLCs, one for each of the 3-5 grades. All of them were led by TL-L, a fully released teacher in an instructional coach position. The PLCs took place approximately once a month, during the last class of the day for about 30 minutes. Teachers met in the school library, with long tables arranged to form a square. The principal, Ms L, left much of the decision-making to the discretion of TL-L.

Analytical Methods

We relied primarily on field notes to characterize each PLC with respect to our analytical categories. Using matrices, we compared the PLCs along a number of a priori and emergent dimensions. We used the TL interviews to provide context and understand their decisions.

Findings: Comparing Uptake of OGAP Practices in PLCs

In this section, we provide an overview of the general patterns of uptake of OGAP practices across the 30 treatment schools to contextualize the five PLCs we studied. We then present our findings on these PLCs update, using the framework presented earlier. We compare these PLCs with respect to a) norms of participations, b) use of OGAP tools and repertoires, and two aspects of shared purposes: c) understanding of formative assessment, and d) shared approach to collaborative inquiry to inform instruction. Using the analytical lenses allowed us to identify different levels of take up. We also consider the role of the TL and other factors that influenced the practices taken up by the PLC.

A Pattern of Low Uptake

Using the OGAP coach reports, we look at the frequency with which OGAP PLCs met across the 30 treatment schools. Overall, we found a modest number of active OGAP PLCs. Only nine schools had at least one PLC that met regularly across the 2015-16 school. We defined these PLCs as highly active because they met once or twice a month to focus specifically on OGAP related work.

We found a number of committed teacher leaders and teachers who attended trainings regularly, expressed enthusiasm for what they were learning, and used OGAP assessment items and other routines in their instruction. These pockets of interest, in many cases, did not translate into regular, active PLCs, often due to contextual factors, including lack of support from their principals, resistance on the part of other teachers, or a general inability to overcome pressures of limited time and resources to fit in a new activity. In these schools, PLCs met periodically, especially at the beginning of the year and then tended to trail off. Some teachers in these schools continued to work with OGAP quietly and in isolation. We defined these schools as

having at least one semi-active PLC if they had at least one active PLC that met a few times during the first half of the academic year, even though participation tapered. We also included schools that had multiple OGAP PLCs that met occasionally or sporadically over the entire year. See Table 2 for break down according to level of activity.

Table 2
Summary of PLC Activity

Categories of School-Level of Engagement	No. of Treatment Schools
At least one highly active PLC	9
At least one semi active PLC	4
Teachers engaged in OGAP, No active PLC	1
Disengaged: No active PLC or engaged teaches	13
Not enough information	3

Our third category included one school that had no formal PLCs or an active teacher leader. Rather this school had a small group of teachers who met informally to work on OGAP related activities. The remaining schools either had no an active PLC or did not grant OGAP coaches access to the school, providing us with insufficient information. The uneven uptake of PLCs is not surprising, given several decisions we made in designing the intervention and the complexity of establishing true PLCs in settings with limited capacity to make them happen. The five PLCs examined for this study were drawn from the nine schools with active PLCs.

Capturing the Variation of Active OGAP PLCs

We analyzed the activities and interactions of each of the five active PLCs with respect to the categories of our analytical framework: a) a sense of shared purpose, b) repertoires for using tools and artifacts, and c) norms that guided interactions and routine practices in the PLC. In this section, we use these analytical categories to characterize the range and variation of the five PLCs with respect to uptake of OGAP practices. Based on our analysis, we have arrayed the five PLCs along a continuum, with low uptake of OGAP practices on the left and higher uptake on the right (Figure 1). It is important to keep in mind, however, that each of these five PLCs met more consistently and exhibited higher general engagement in OGAP than most others in the study. Our analytical focus is on the extent to which the PLCs took up practices likely to support the use of OGAP approaches and the factors that contributed or inhibited the PLC quality.

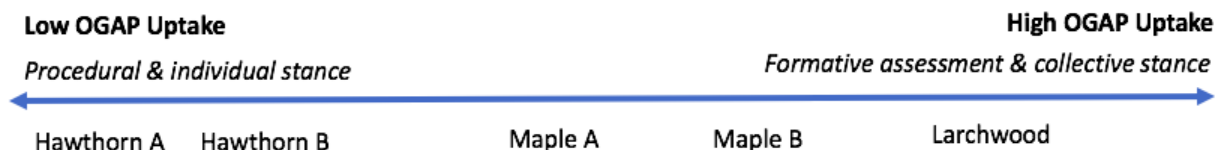


Figure 1: Variation in OGAP uptake of the five PLCs.

In the following sections, we elaborate on our placement of each PLC along this continuum, using the following categories: Norms of engagement, OGAP repertoires, and shared purpose. Using these categories, we introduce each PLC and illustrate their typical practice.

Norms of participation. When considering norms of participation, we looked at the general approach to participating among the members of the PLC, including the routines and structures in place that supported or constrained the ways they interacted. We also looked at how group members initiated or took up conversations and how disagreements (if any) were navigated. In this category, higher quality OGAP PLCs would not only have routines or norms in place that support mutual engagement in collective activity, but that collective activity would involve inquiry into student thinking through examining student work and discussions of next instructional steps. It might also involve inquiry into the mathematical ideas represented in the framework or student work. Our analysis considered the extent to which these norms were established and how broadly they were embraced by all participants in the PLC.

Across the five PLCs, all had established routines for preparation and launching the meetings; the teachers routinely brought student work and were prepared to sort and discuss it. The differences we found were in the extent to which these routines involved collaborative participation and where the locus of control and knowledge resided. These are arrayed in Figure 2. Below we provide descriptions of each PLC to illustrate their placement on the continuum. The first descriptions are extended, to provide a feel for the PLC meetings. The subsequent descriptions are brief.

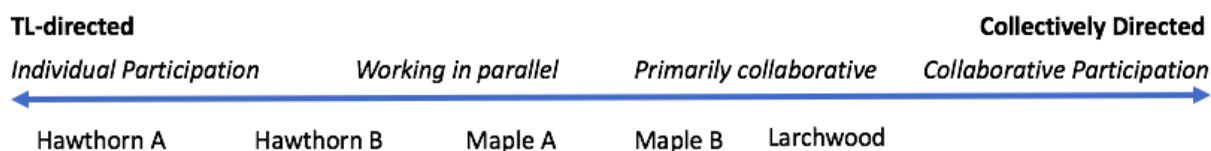


Figure 2: Continuum of norms of participation in OGAP inquiry

We placed the two Hawthorn PLCs on the left side of the continuum, which emphasizes individual and teacher-leader directed norms of participation. The *Hawthorn A* PLC (Gr 4-5) is further to the left than Hawthorn B (Gr 3) because of its individual structure. The 4-5 participants of this PLC, who taught grades 4, 5, and special education, did not attend the sessions consistently, and not all of them brought student work each time. The completed items they did bring, were also different from one another because they taught different levels of students. As result, the discussions of the student work and their implications for instruction were always between the TL (Ms. D) and the particular teacher. The following PLC description of participation is from the session on 4.13.16. The grade 4 math and a special education teacher were present, along with Ms. D, who was the grade 5 math teacher. On this particular day one teacher had left her student work at home. The norms of participation were typical of all Hawthorn A PLCs.

Ms D sat at the head of the conference table with her laptop open to a digital copy of the PLC agenda provided at the teacher leader training, that listed the activities of a PLC (the OGAP cycle) in order. She turned to the teacher on her right, read aloud the item numbers he had agreed to give students, and asked, “What do you have?” The two of them looked over the items together, which he had presorted, identifying concerns or patterns, which Ms D recorded on her laptop. Ms D did much of the talking, summarizing her observations: “They understood arrays....” The teacher agreed, “yes, when I was able to break it down for them.” After 2 or 3 minutes on each of two items, Ms D turned the conversation to the next step in the OGAP cycle, reading from the PLC guide she had received at a training. “What evidence of developing understanding can be built upon?” She then proceeded to suggest ways the teacher could use, including reviewing the steps with them. The grade 4 teacher was present during this conversation, eating a salad, but did not participate, until this point, when she suggested using manipulatives. Ms D agreed. She then suggested they select items for next time. Accessing the OGAP Item Bank from her laptop, Ms D found two items the teacher could use next. They discussed what students might have difficulty with and how he might modify them.

Ms D pulled out her own set of items and began to sort through them, occasionally voicing surprise by student responses. She did not engage the others in looking at the student work, in fact her laptop was positioned so that it would have been hard for them to see what she was looking at. She recorded notes on her students, while the other two teachers chatted quietly. The fourth grade teacher pulled older completed items from her began and began to enter the results into her eTool. After selecting and recording the numbers of two items she would give her students, Ms D turned to the fourth-grade teacher to discuss items for her students. She recorded all the group’s decisions on her laptop, speaking aloud as she types. When finished, she looked up and asked, “Do we have anything else?” They didn’t, so she confirmed the next meeting date, emailed the PLC record she had been typing to the teachers, and the meeting ended, 25 minutes after it had begun.

The *Hawthorn B* PLC was similar to the Hawthorn A PLC in structure, since it was also directed by Ms. D. They lasted about 25 minutes, moved fairly quickly, and were heavily steered by the TL. The teachers arrived with their items presorted, which Ms.D expected, and much of the conversation involved teachers attending to their students' work. Nevertheless, the participation was less individualized because the two regular participants were both grade 3 teachers and brought student work on the same items. They did not often look at one another's work, but tended to find similar errors or misconceptions that they discussed with the TL. We labeled the norms of participation for this PLC as working in parallel. However, because they were able to focus on their student work on the same items, this PLC included more detailed discussions of student errors than Hawthorn A. For example, on 3.07.16, the two teachers were discussing their students' work on a partitioning item with the TL: [The item showed an open rectangle and the following prompt: Shade one fourth of the figure].

One teacher noted that many students were partitioning the figure into fourths, but not all had done so correctly or tended to shade more than $\frac{1}{4}$. The TL asked whether the students had partitioned the figure correctly. "If they are not partitioned correctly," she went on to explain, "they are early fractional stage." She reminded them of this point, which had been raised in their recent training. They agreed that most had done so correctly, but not all. The other teacher said she had found the same thing, "a little bit of trouble with the partitioning," showing an example. They all wondered whether this trouble reflected lack of experience with art or drawing, rather than indicating something about their understanding. TL noted these patterns in her notes before going onto the next item.

Typically, the Hawthorn B PLC spent up to 12-15 minutes discussing the items they had brought before moving onto the next phase of the PLC, determining what understanding they could build on. Similar to the Hawthorn A PLC, this phase was heavily directed by the TL and consisted of her offering suggestions to the teachers and recording them in her notes, such as "Build on fraction reasoning or use area models and number line." The final phase of this PLC involved selecting items to give the students next. Ms. D typically searched the item bank for appropriate items, turning her laptop toward the teachers for their approval.

We placed *Maple A* towards the middle of the continuum, labeling their participation as primarily collaborative, because the participation ranged from working in parallel to working collaboratively. Similar to Hawthorn A and B, there were several instances where this PLC focused on parallel work, all of the teachers in the PLC first sorted their own student work, with little to no discussion with one another, until the TL moved the group to discussing their individual results. From there, the teachers would talk with one another about student work and any broader patterns they may be experiencing. We did not categorize this PLC as fully collaborative because there were times during OGAP activities when teachers worked alone or in separate pairs. Also, one teacher in the group tended to distract the TL from the OGAP activities, engaging her in conversation. The following PLC description of participation is from the session on 4.30.16, which lasted an hour, as was typical. During this observation of Maple A, four 5th

grade teachers in addition to TL-M were in attendance. Two were classroom teachers and the other two were specialist instructors. All but one of the teachers had brought student work, using the same item for all the students.

Both Maple PLCs met in the same classroom, but in different areas. The group sat in five desks, which had been moved into a cluster, with TL-M sitting at one of the desks. On her desk, she had placed an iPad with the OGAP items, a copy of the Fraction Framework, and a blank PLC agenda provided in the OGAP leader training. The first few moments of the PLC consisted of teachers talking with one another about non-OGAP topics, such as upcoming school events and student issues. Once everyone was seated, TL-M asked the teachers to take a moment to sort their work, and then discuss some of examples. One teacher recalled that while answering the item, her students asked her if the answer should be “a fraction or converted into minutes” and she told them to take into consideration the context of the problem. Another teacher replied, “converting into minutes is more impressive than [leaving as a fraction].” She went on to describe how her students struggled because the item did not have a “clue word” to let the students know what operation to apply. “A lot of my kids did multiplication instead of division,” she said. The first teacher agreed, “Exactly.” The teachers all begin to talk about how their students were misunderstanding the problem, and looking for clues that were not there. They noted that many of their students added and multiplied when they should have been dividing.

After the discussion, one teacher reported to TL-M, “I had twenty-four kids take it, I had seven who got it completely right.” TL-M took down the numbers in her notes. The teacher continued as TL-M took notes, “Nine of them multiplied, instead of divided and eight just had no idea.” After looking further at her notes, the teacher said, “Honestly the biggest issue they had was converting a mixed number into a fraction.” Other teachers looked at their own piles to see if students made similar mistakes and found that they had. Teachers also compared their student work to see how other students answered the question. The teacher leader asked clarifying questions, or highlighted what another teacher had said. Throughout the session, three of the teachers appeared engaged in the conversation. The other teacher, however, did not participate, but tried to initiate a separate conversation with the TL-M, discussing how technology hinders student learning.

Near the end of the session, Principal M entered the room where both Maple PLCs were meeting. He circulated around both groups before calling for their attention. He held up two examples of student work (taken from the Maple B PLC) and asked teachers to explain the differences between two pieces. A teacher from Maple A consulted her OGAP framework and identified the difference in “magnitude thinking.” At least one teacher from Maple A crossed her arms and appeared to disengage from the conversation. The principal suggested that for next steps, teachers pair students together based on the way they answered the item so they could explain their strategies to one another. The PLC ends without an official closing; two teachers talked about their student work and the others conversed about non-OGAP topics.

We placed *Maple B* further to the right on the continuum, labeling the PLC as collaborative. Although both PLCs met concurrently, Maple B teachers spent the majority of the

time working and interacting with one another. Further, during that time, all teachers were engaged and focused on OGAP activities. The following description is from the session on 4.30.16. Four 5th grade teachers were present, in addition to the TL-S.

Similar to Maple A, the members of Maple B sat at five desks, clustered around one another. The Teacher Leader had an iPad with the OGAP items, a copy of the Framework, and a blank PLC agenda. All of the teachers had brought copies of the Framework and student work on the same item, including the TL-S, who was also a classroom teacher. The PLC began with a few announcements made by TL-S. Then the teachers began to sort their student work, referring to the framework. One teacher in the group had recently returned from maternity leave and was unfamiliar with the Framework or OGAP system. The TL-S explained the fractional learning trajectory to her, finding examples from her student work to illustrate aspects of the Framework, including the models or algorithms students used. Other teachers began to listen in and offered examples from their student work to illustrate TL-S's explanations.

Partially through the session, TL-S directed the other teachers to focus on the students who are non-fractional and look at the mistakes they were making. Similar to Maple A, all of the teachers gave the principal their attention when he entered and asked them to compare and contrast examples of student work. Unlike Maple A, the Maple B PLC returned to their discussion of their student work once the principal left. At the end of the PLC, the teacher leader closed the activities by asking "next time we come together what questions do you want to look at?" Several teachers made suggestions, which the TL-S recorded. She then began to talk with one teacher about instruction.

We placed *Larchwood* at the right end of the continuum, due to their consistent collaborative and self-directed approach to participation, both procedurally and dialogically. Teachers exhibited collegial behaviors in at least three ways. First the PLC exhibited shared norms with the standardization of the activities within the meeting. For example, most PLCs began with all of the teachers seating themselves at the table and taking out a piece of scratch sheet of paper (amidst greetings and pleasantries). Each teacher then solved the math problem that corresponded with the item in the student work they brought, and took a moment to discuss their answers with one another. Second, the activities appeared to be self-initiated, with teachers moving from one activity to the next with little guidance from the teacher leader. Third, teachers were collaborative in their work. All teachers utilized the same math item, sorted the work individually, but unlike both Hawthorn PLCs, they discussed their findings with one another during the process. Similar to Maple B, the teachers in the Larchwood PLC spent the majority of the time working on OGAP specific activities. Unlike Maple B, teachers in the Larchwood PLC seemed comfortable enough to offer alternative interpretations of the student work and occasionally asked questions to further their understanding of the concepts, without the prompting from the teacher leader.

The following PLC description of participation is from the session on 4.6.16. During this observation, six 4th grade teachers were present, in addition to TL-L. Like all PLCs we observed at Larchwood, this one lasted 30 minutes.

The 4th grade PLC for Larchwood took place in the school library where there were four long tables arranged in a square with seating all around. Teacher Leader L sat at the center of one of the tables, alongside a notebook, her iPad, and a basket of chocolates which she placed off to the corner of the table. As teachers entered the room, many of them seemed cheered at the sight of the candy and took a few pieces with them to their seats. They greeted one another and almost immediately began talking about student work. Each teacher then solved the math problem that was the item of the day in the student work, and took a moment to discuss their answers with one another. One teacher even began sorting her work before other teachers arrived. Once every one was seated, and initial greetings and announcements were made, the teachers sorted student work. As they sorted their work individually, they talked about how students solved the problem and how they sorted. One teacher explained that she sorted her work in the following categories: used algorithm, used pictures, got the right answer, and got the wrong denominator. TL-L suggested they focus on correct answers over wrong answers first. She then encouraged them to consider the reasons why students gave the answers that they did. One teacher suggested that the student work reflects the teacher's instructional approach.

Unlike the other PLCs in this study, Larchwood teachers were comfortable disagreeing with one another, and even occasionally with the teacher leader. The overall tone was respectful, but teachers seemed comfortable enough to express their views.

Use of OGAP tools and repertoires. High-quality PLCs use specific tools to support their work and their use of these tools is guided by a set of repertoires for their use. Cobb et al. (2003) used the phrase “a well-honed repertoire of ways of reasoning with tools and artifacts” (p. 15). In our analysis, we considered the use of OGAP tools, such as assessment items, frameworks, terms, and the steps of the formative assessment cycle. We also looked at the ways they engaged these tools, the depth and consistency with which they took up OGAP practices for analyzing students' mathematical thinking and determining instructional responses.

In each of the five PLCs, we saw evidence of OGAP tools and practices. The majority of teachers gave their students OGAP items and brought student work to the meeting. We did uncover differences in the consistency of tool use and the depth with which tools were engaged by all members of the PLCs. The continuum in Figure 3 reflects the range we found from underdeveloped and not fully shared to fully developed and shared repertoires.

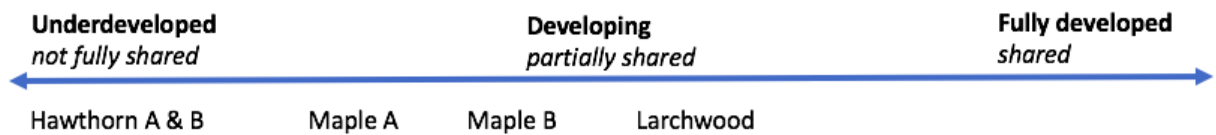


Figure 3: Continuum showing extent to which repertoires for tool use are developed and shared

Both Hawthorn A and B PLCs are placed on the left side of the continuum, under the heading underdeveloped and not fully shared, because we saw limited evidence of the use of OGAP tools and repertoires and when they were used, it was most often by the TL. Although all teachers gave students OGAP items on a regular basis, we did not see consistent use of OGAP frameworks or language during the meetings. Typically, when teachers sorted the student work, they did so based on correctness or type of error and did not refer to the levels of multiplicative or fractional understanding shown on the framework. We observed just one instance of a teacher using a framework to sort student work. This instance occurred during a Hawthorn A PLC, when the TL was working with the special education teacher on his items. While waiting, the 4th grade teacher sorted her student work. At one point, she took out her framework and studied it briefly, then placed the piece of student work in a pile, and tucked the Framework back into her bag. We also observed the same teacher entering results of an assessment into the eTool during another meeting. Neither of these tools was brought into the conversation during the PLC.

As illustrated above, both PLCs at Hawthorn were heavily directed by the TL. She appeared to hold most of the knowledge about OGAP terms and processes and was the only one who used OGAP language to describe student work, such as transitional, unit-fraction reasoning, etc. She used these terms to describe patterns in the work and when taking notes on the meetings, but there was no discussion of their meaning with the other members of the PLC. The formative assessment cycle (assess, analyze, respond) is an OGAP repertoire intended to guide the structure of PLC meetings. This cycle is described on the PLC agenda that TLs received during the leader training. TL-D followed the sequence of this cycle when structuring the meetings, but devoted very little time to responding, the part of the meeting intended to discuss instructional responses based on the assessment of student thinking. Typically, TL-D made a few suggestions, which tended to be vague, such as “build on the numberline and partitioning” (4.18.16 PLC notes). During the 3.07.16 meeting of Hawthorn B, described earlier, the TL and teachers were surprised by an error many students made on a fraction item. The TL suggested both teachers sit down with their students and ask them to explain why they did not choose C. More time in each PLC was devoted to selecting the next assessment items to give, which the TL also closely directed, than determining appropriate instructional responses. In sum, the TL appeared to hold a great deal of knowledge of OGAP tools and structures, but she did not share it with the other PLC members.

We placed both Maple A and B PLCs at the center of this continuum, under developing and partially shared use of OGAP tools and repertoires because learning to use these resources appeared to be a work in process. In both PLCs, we observed consistent use of OGAP tools, including items and the Frameworks, and some use of the eTool. As described earlier, teachers spent time during each meeting sorting student work according to the Framework and discussion what it indicated about students. Some teachers accessed resources on the eTool during the meetings. At the same time, familiarity with OGAP approaches and terms was uneven. Some teachers had attended all of the OGAP professional development, while others only attended some or none and many appeared to struggle when sorting student work. In both PLCs, teachers with some knowledge of OGAP actively worked with those who were less experienced. For example, during our observation of Maple A, a teacher took her own presorted work, shuffled the papers, and distributed the papers among the other teachers and encouraged them to sort the work based on the Framework. In our observation of Maple B, the TL worked with a teacher who had just returned from maternity leave. Within a few minutes, other teachers joined this conversation, offering examples and explanations.

Similar to the Hawthorn PLCs, the Maple PLCs tended to spend the majority of time sorting student work, leaving less time for instructional responses. They were also quick to move to selecting the next item. During at least two observations, the principal played a role in moving the discussion to instructional steps. As mentioned earlier, he routinely visited the PLC meetings during the last 15 minutes and often engaged both groups in a discussion of student work and instructional response.

Interestingly, not all teachers in the Maple PLCs saw themselves and learning to use OGAP approaches. Several teachers in Maple A did not view themselves as being part of OGAP. One teacher explained that she had “never been part of OGAP” but had attended all of the PLCs and had attended some of the trainings.

We placed Larchwood to the right end of the continuum due to both the consistency and breadth of use of OGAP tools during PLCs. All teachers regularly arrived with a completed set of recent OGAP items that they could offer to be sorted by the whole group. Beyond preparation, the process for the PLC was equally clear and followed. Teachers solved the problem given to the students on the OGAP item. Then a single teacher’s set of student work was selected and sorted by the group, first by correctness, and then by sophistication of strategy using the OGAP framework. In some instances, the PLC members were able to develop next steps or would have deeper conversations about specific mathematical elements (such as the meaning of equivalency and how to relay that to students), but these were not part of the routinized elements of the PLC.

Shared purpose: understanding of formative assessment. Wenger (1998) and Cobb et al. (2003) suggest that the extent to which the conversations among members of professional communities

is influenced, in part, by whether they are engaged in a joint enterprise and the extent to which that enterprise addresses “taken-for-granted aspects of school life” (Wenger, p. 76). Formative assessment is the aspect of school life that is core to the OGAP approach. Taking up formative assessment perspectives and practices includes shifting from a view of students’ work as either correct or incorrect, or as indicators of whether they “get it” or not, to a view that student work can provide insight into what they understand and where their thinking is along an empirically developed learning progression. One of the goals of the PLC process is to develop an understanding of formative assessment and a formative assessment mindset through engaging teachers in assessing student work and using findings to make instructional decisions. Our findings suggest that making this shift was a challenge for most of the PLCs.

Across the five PLCs, we found a general focus on correctness, but some of the PLCs were also ready to move beyond simply considering whether students’ answers were right or wrong to explore deeper understanding. The continuum in Figure 4 represents this range, showing that none of our PLCs had fully relinquished a correctness-first perspective when looking at work student thinking. Even for the PLCs that attended to student strategies, they tended to sort the strategies descriptively, rather than taking a developmental lens for looking at student thinking (Ebby, 2015).

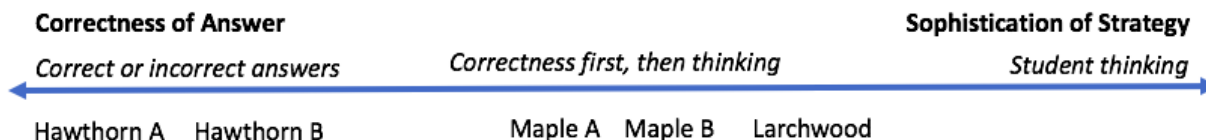


Figure 4: Continuum showing PLCs emphasis on correctness versus student thinking.

Both Hawthorn PLCs tended to focus on correctness or proficiency (Ebby, 2015) when looking at student work. They used language like “got it” or “these students understood.” When students produced correct answers, they tended to be satisfied and did not dig more deeply. When students produced incorrect responses, like placing fractions incorrectly on the numberline, they spent some time discussing the nature of the errors, focusing on what the students did not understand or were confused about. Even though, during each PLC, the TL asked the question following question from the PLC agenda, “What evidence of developing understanding can be built upon?” the discussion rarely focused on instructional approaches that built on student understanding.

We put both Maple and the Larchwood PLCs toward the right end of the middle of the continuum due to their consistent split focus between correctness and sophistication of strategy. Both Maple PLCs focused first on the correctness of student work before examining the work for evidence of student thinking. However, once they moved past correctness, the teachers looked at

ways the students were solving the problem, using terms like non-fractional, early-fractional or transitional to describe their assessments and giving the number of students placed in each group. During one meeting, Maple B teachers realized that few of their students used visual models to explain their answer, rather they “went straight to the algorithm.” This observation led to a discussion about getting students to use different ways to solve the problem.

The Larchwood procedure for examining student work was a two-step process, involving both ends of the continuum. First, teachers sorted the student work by correctness, making piles of correct and incorrect work. Then, teachers examined only the correct student work and sorted them based on the sophistication of strategy used. While Larchwood exhibited both a focus on correctness and sophistication of strategy, a clear premium was put on the conversation around sophistication. The correctness sort tended to happen quickly and did not elicit much discussion. The sophistication sort led to richer discussion and was typically the time in the PLC when productive disagreements emerged. We placed Larchwood on the right side of the middle on the continuum due to the greater value they appeared to place on the sophistication of strategy.

Shared purpose: collaborative inquiry to inform instruction. A second intended purpose of OGAP PLCs was to provide a site for collaborative inquiry into student learning and teaching practices. Through looking closely at student thinking and their developing understanding of mathematics, the aim is that teachers will develop an inquiry perspective toward their instructional decisions, that is a view that teaching decisions should grow out of evidence-based investigations of students’ understanding and needs. A further aim is that through engaging in such investigations with others, teachers will develop as an inquiry community in which ideas and learning of all members are valued. Considering our data collection took place near the end of two years of implementation of OGAP PLCs in participating schools, we were curious about the extent to which these highly active PLCs appeared to embrace a shared purpose around inquiry into student learning and related teaching decisions.

We found differences across the five PLCs in how the work of the PLC was understood and the extent to which this work was consistently embraced by all members. These differences are represented in the continuum in Figure 5.



Figure 5: Continuum showing extent to which PLCs embraced shared purpose of inquiry.

We categorized both Hawthorn PLCs as focusing on compliance. The teachers in each group attended their meetings regularly and usually brought student work to analyze. The support of the school principal was evident in that he adjusted the schedule to accommodate OGAP participation. In their interviews, teachers expressed appreciation of the opportunity provided by OGAP. At the same time, we observed a general sense of compliance associated with their participation. This sense was communicated primarily, but not exclusively, by the TL. In her interview, she made reference to the “requirements” associated with the PLC, like coming on time, sorting one’s work in advance, etc. In addition to supporting of the teachers in each PLC, she viewed her responsibility as ensuring that the school complies with its obligations to the OGAP project. As previously mentioned, the TL took notes on the decisions made at each stage during the PLC. When completed, she emailed the notes to all teachers, the principal and the OGAP coach. A tendency toward compliance was also reflected in the fact that meetings were short (about 25 minutes) and appeared to be comprised of moving through a set of externally imposed steps.

We placed the Maple A PLC in the center, under uneven investment in inquiry because of the different views of purpose of OGAP and the PLC expressed by the members of the group. Two of the Maple A teachers showed sustained interest in the overall formative assessment process and inquiry into student learning. These teachers tended to be the most prepared for each meeting and continued their OGAP activities after interruptions. During one observation, these two teachers discussed student work and mapped it onto the framework, consulting one another about whether their interpretations of the student work was accurate or when questions emerged. In one case, they discussed how to place a piece of student work that included the correct numerical answer, but the incorrect unit. Two of the teachers were less engaged and inclined toward disrupting or rejecting the formative assessment cycle during the PLC meeting. One teacher, for example, when the conversation moved from analyzing student work to instructional responses, stated, “We’re done with fractions; we’re moving on.” As mentioned previously, one teacher claimed to not be part of OGAP and had not attended any training.

Maple B, working in the same room as Maple A, but with a different teacher leader, demonstrated a more consistent and shared investment in inquiry and more sustained interest in the work during the length of each PLC. We placed it on the right side of the continuum. All teachers in the PLC remained engaged the entire time and interacted with one another to interpret student work and consider the underlying mathematical issues. During our second observation, we watched the teachers in this PLC work together to understand the different ways that students interpreted the question and the different answers they provided. During the second observation, the teachers had an in-depth conversation about evidence in student work that qualified it as indicating “fractional” understanding. As the teachers spoke with one another, they also incorporated information from previous discussions about other OGAP topics, including the classifications used in the multiplicative reasoning framework.

We also placed Larchwood on the right of the continuum, under shared investment in inquiry. As has been illustrated in the previous examples, this PLC was inclined to explore both mathematical ideas and student strategies in deep ways. Across our observations, we found that the members of this PLC saw it as an opportunity to learn with one another. Because the PLC sessions began with joint work on a math problem, followed by collective sorting of one teacher's set of student work, the atmosphere appeared to be collegial by design. As they went around the group, each teacher shared his or her view on the student work or expressed disagreement with a previously stated interpretation. During these discussions, it was not uncommon for teachers to disagree on an interpretation. Although it was not made explicit, tacit norms around comfort with conflict were evident. The ability among the PLC members to remain a collective environment, as disagreements about student work surfaced appear to catalyze the discussion, requiring each participant to point to evidence and further explain their point of view. In this way, the PLC had adopted an approach to shared inquiry.

Implications for Opportunities to Expand OGAP Practices in PLCs

An explicit purpose of the OGAP PLCs was to support the use of OGAP at the treatment schools by providing an opportunity for collaborative use of OGAP tools and routines. The variation across these five PLCs suggest that they offered substantially different opportunities for teachers to learn about and expand their use of OGAP tools and understanding of formative assessment. In this section, we discuss the nature of these opportunities and speculate on the factors that influenced them. Our focus is on the extent to which the practices in each PLC provided opportunities for further growth, even if their uptake of OGAP practices was low at the time.

Limited Opportunities to Learn

Both Hawthorn PLCs appeared to offer limited opportunities for expanding OGAP uptake. As discussed above, they both emphasized procedural approaches to OGAP tasks and interpreting student work. This tendency, however, is not uncommon for many teachers who have not been exposed to learning progressions (Ebby, 2015) and is not necessarily a barrier to further growth. That said, the Hawthorn PLCs, especially A, included few generative practice, likely to prompt future growth. For Hawthorn A, the fact that they never looked at common student work served as a barrier to collaborative exploration of student thinking. The TL was their primary source of alternative ideas or ways of thinking. The TL took a managerial to leading the PLC, rather than a collaborative one. Although she had a great deal of knowledge of OGAP, she did not share it with her colleagues. Her efforts to support them and avoid putting too much pressure on them, worked against creating shared knowledge and repertoires.

Certain features of the Maple A PLC also constrained the opportunities for learning. Like Hawthorn B, the Maple A teachers all brought the same student work to the PLC, but the

dynamics of the group were complex. In addition to including one or two teachers who were resistant to, the Maple A TL was a literacy coach and had limited expertise. As a result, she expressed discomfort pushing the teachers during the meetings.

Opportunities to Extend Knowledge of OGAP

In contrast to Hawthorn, the Maple and Larchwood PLCs provided stronger opportunities for teachers to learn about OGAP routines and approaches. The OGAP tools were made available to all teachers. OGAP items and the framework were the focal activity of the PLC sessions and substantial time was devoted to sorting students work using the frameworks. These characteristics provided teachers with opportunities to become familiar with them. Because these PLCs were structured so that all teachers looked at student work on the same items, it created a context for shared exploration. In the case of the Maple PLCs, the principal played a surprising and conflicting role in supporting opportunities for learning. He routinely visited the PLCs during the last 15 minutes of the 50 minute session and tended to step into the leadership role. For the time he was present, he brought both PLCs together and prompted the teachers with specific questions about samples of student work and appropriate instructional responses. At once, his questions pushed several teachers to focus on the instructional response phase of the OGAP cycle and his presence ruffled the feathers of some teachers who were part of Maple A.

Opportunities to Extend Understanding of Student Thinking and Mathematics

From our analysis, it appears that Larchwood was unusual in its focus on mathematics and inquiry into student thinking. This was the only PLC we observed where the teachers worked on the math problem together, prior to sorting student work on the same problem. This math work appeared to lay the groundwork for focused conversations about student understanding. The fact that the TL encouraged participants to go beyond right and wrong answers when analyzing student work also encouraged the group to delve into the mathematical ideas. The Larchwood TL made an effort to establish a collegial and supportive atmosphere. It was also apparent that strong relational bonds existed between the teachers, evidenced by their open conversations before and after meetings. The strength of the existing relationship may have made it possible for teachers to take risks when interpreting student work. This was the only PLC where we saw teachers offering alternative interpretations of the students' solution and willingness to disagree. For these reasons, the Larchwood PLC not only appears to support teachers' learning about OGAP tools, but has the potential to foster understanding of student thinking and mathematical ideas.

Conclusion

The low uptake of OGAP PLCs across the 30 treatment schools serves as reminder that initiating even modest organizational change in school systems experiencing extreme capacity challenges is an intractable problem. Increasing the implementation of OGAP PLCs would require a greater

investment in supports and coordination within the school systems and among school leaders, an approach we are using in a follow-up study currently underway.

On the other hand, our analysis of the learning opportunities available through the five PLCs analyzed suggests that these school-based structures can create generative opportunities for learning when the conditions are right. Those PLCs that were most likely to support ongoing learning allowed sufficient time to meet, were guided by leaders who had a strong understanding of the goals of OGAP and its tools and routines, and provided teachers with multiple opportunities to use these tools and routines in common with one another.

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