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Understanding Quality Work in Mathematics: Supporting Teachers in Leading Professional Development

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Abstract

Teacher leaders are often responsible for providing professional development to improve teacher effectiveness and student learning. Leading professional development for teachers can be highly effective when the focus is on student learning in on-going and relevant contexts. This article describes a school-based, teacher-led collaborative process conceptualized and facilitated by two teacher leaders using a modified protocol for examining students work in mathematics. The focus of the professional development aligned with a school-wide initiative of increasing the quality of students' mathematical work across a kindergarten through eighth-grade school. This paper shares the structure of the professional development, the nature of the protocol, and how it was implemented followed by a discussion for teacher leaders who are interested in facilitating a similar type of collaborative professional development experience within their own schools. Findings suggest that the use of a well-developed protocol helped focus teachers' attention to specific attributes expected in quality work and served as a reference point for considering how important structures of learning such as whole-class discourse could be evident in individual students' quality work.

Keywords: *Mathematics, Professional Development, Teacher Leaders*

INTRODUCTION

Highly effective schools are in a continual state of improvement and effective leadership is at the heart of this work. Leadership is not about an individual or a team of identified people, but a process. "For the process to be effective, those who direct or facilitate it—the leaders—must act in ways that engender a positive dynamic between them and those with whom they work" (Balka, Hull, & Miles, p. 5). Thus, a teacher leader is an individual who supports, guides, and influences others to accomplish the shared goals. This means a teacher leader can be teachers, coaches, curriculum experts and/or administrators.

Teacher leaders frequently support teachers to meet the goals and complexities of school reform through professional development. However, when these experiences are rooted in teachers' practice and teachers have opportunities to make decisions around their practice and the professional development, the experiences become key moments in their own continual professional growth as well as school-wide advancement in identified initiatives (Desimone, 2009; Wilson & Berne, 1999). As such, teacher leaders play a critical role in facilitating this work without taking over the process. This also means that teacher leaders need to understand the nature of professional development processes and the nuanced aspects that can help guide teachers' efforts in this work. This paper describes how one group of teacher leaders structured a focused, job-embedded, and teacher-led professional development experience centered on the school's goals in mathematics. This work focused on using students' mathematical work as a means of collectively understanding the nature and construct of quality work. This also

allowed the teachers to develop more refined understandings of how best to support students across grades in creating quality mathematical work.

REVIEW OF LITERATURE

Professional Development

Much of the current research on professional development indicates that it consists of several key factors that mutually support and build upon each other. Specifically, effective professional development should be on-going, embedded within a classroom context, and be collaborative in nature (e.g. Desimone, 2009; Guskey 2002; Marrongelle, Sztajn, & Smith, 2013). This represents a major shift from the "hit and run" design and delivery of professional development historically offered. Additionally, professional development should be aligned to schools' identified areas of need (Marrongelle, Sztajn, & Smith, 2013). That is, if the teachers do not understand how the intended learning of the professional development fits into their specific context, and if such work is not additionally supported by school or district administration, then change in practice will be less immediate. A connection from the professional development back to teachers' context, and the discussions the teachers have with their colleagues within their school, further ground the importance of the professional development to their practice. This further supports the need for professional development to be inclusive and led by teachers with teacher leaders serving as a facilitator of the process, not the source of knowledge.

Examining Student Work

Professional development should also be focused on student learning (Garet, Porter, Desimone, Birman, & Yoon, 2001; Hiebert, 1999). This means providing opportunities for teachers to closely examine student thinking and understand the nuances and salient aspects within their work and not just the pedagogical techniques to improve student learning. In fact, Hull, Balka, and Harbin-Miles (2011) indicate that attending to student thinking and making it a central point is key to learning mathematics. Attending to student thinking can take many forms and can occur in many contexts, including such things as lesson study-type situations (Lewis, Perry, & Murata, 2006) or engaging the class in whole-class discourse to better understand how students think about the mathematics (Author, 2013). Additional research has shown that collaboratively analyzing student work is another means by which this can occur (Blythe, Allen, & Powell, 2015).

Examining student work can influence professional discussions about teaching and learning. In turn, this can engage teachers in a cycle of experimentation which becomes a starting point for reflection that focuses on student outcomes rather than instructional pedagogy (Kazemi & Franke, 2004). Additionally, the process of examining students' work encourages teachers to approach teaching and learning through an inquiry-based lens and thus helps increase teachers' skill in attending to the words, actions, and ideas of students that are most important in formulating next steps to support mathematical learning. By examining student artifacts in mathematics, teachers are better able to use specific evidence of learning to reflect on their instructional practice (Goldsmith & Seago, 2011) and provide specific feedback to help students routinely create quality work (Hounsell, McCune, Hounsell, & Litjens, 2008).

Using a Mathematical Quality Work Protocol

Various protocols can be used to examine student work (Allen & McDonald, 2003; Blythe, Allen, & Powell, 2015; Easton, 2009; EL Education, 2015) but most protocols are not specific to the teaching and learning of mathematics. For this study, a modified version of the Quality Work Protocol, which, in its original form, is not

subject-specific and defined quality work through the lens of complexity, craftsmanship and authenticity (EL Education, 2015), was adapted for mathematics. Specifically, the adapted version retained the categories of complexity, craftsmanship and authenticity, but adapted the attributes specifically for mathematics student work by integrating key aspects of high leverage teaching practices in mathematics (National Council of Teachers of Mathematics, 2014; National Research Council & Mathematics Learning Study Committee, 2001). The actual steps and timing of the original protocol were used and the adaptation became the Mathematics Quality Work Protocol (MQWP), as seen in Appendix A.

Though the school in which this study takes place, called "Academy West," (pseudonym) has used other protocols for analyzing students' quality work, the focus had been on long-term and culminating products created as part of project-based learning and not directly related to mathematics. It became clear to the teacher leaders and the teachers at this school that there was a need to better understand how teachers across grade levels collectively viewed quality mathematical work so they could be more systematic and deliberate in supporting students in creating high-quality mathematical work on a regular basis regardless of grade or mathematical content.

METHODS

The purpose of this study was to better understand how the process of attending to student work in mathematics helped teachers develop a shared understanding of the nature and elements of quality work in mathematics to support one school's initiative centered on helping students continually create quality work. The guiding research question for this qualitative study focused on understanding the extent to which a modified quality work protocol for mathematics helped teachers define quality student work through examining the complexity, craftsmanship, and authenticity of their work. Specifically, the research questions for this qualitative study was "How does a modified quality work protocol help teachers define quality work in mathematics?" This study used a grounded theoretical approach (Corbin & Strauss, 2007) to allow for the development of understandings based on multiple qualitative data sources, including observations, field notes, and artifacts developed from the professional development experiences.

Observations and Fieldnotes

Observations were conducted during the teacher-led professional development experiences using the MQWP. While the researchers attended the professional development experiences, their primary role was to facilitate the experience and only intervene if salient perspectives were not being considered or if agreed-upon norms were being overlooked. The experience was strategically placed during the first half of the school year, after teachers were able to establish routines in the classroom, and had student work to examine. The timing was important to teachers so that they could conduct the protocol early enough in the school year to be able to make any course corrections immediately based on the examination of student work.

Additionally, the researchers wrote descriptive and reflective field notes during and after the professional development experience (Creswell & Poth, 2017). The professional development experience, using the MQWP, lasted two and one-half hours due to the richness of the discussion and the connections being made by the participating teachers. These notes focused on teachers' interpretations and understandings derived during the discussions about the nature and structure of quality student work. These notes also captured data that was otherwise not conveyed in teachers' collaborative written reflections or recorded notes, which were part of the professional development experience.

Implementing the MQWP

Because the protocol required teachers to discuss the quality and nature of student work, which can be influenced by personal experiences with their own students, the teachers agreed upon norms at the beginning of the year in order to engage in as objective of conversations as possible. These norms were displayed prominently during all professional development experiences and were reviewed and discussed before the MQW protocol paying careful attention to the details of what the norms would look like and sound like during their work.

To begin, teachers collected and displayed student work in mathematics; the type of work was not specified and teachers chose daily work samples, multi-day investigations, and long-term projects. Teachers brought three of each piece that, according to their rubrics, met but did not exceed, the content standard(s) being assessed. In the first round of the protocol, teachers utilized the MQWP as they silently examined the student work individually, thinking about and taking notes on the degree to which work samples showed attributes of complexity, craftsmanship, and authenticity along with a justification of their thinking. Teachers then moved into multi-grade level groups to discuss those observed patterns related to each attribute. Then, as a whole group, teachers shared observations and created a list of patterns related to each attribute, noting which attributes were strengths at the school, and which could be a focus for future improvement.

In the second part of the protocol, teachers displayed the rubric, scoring guides, and any specific task descriptions that accompanied the student work. Teachers again examined the work, taking notes on the three aforementioned attributes of quality, this time focusing on the tasks and scoring rubrics associated with the student work and how those supported quality. Teachers first noted patterns individually and then in multi-grade collaborative groups before moving to a whole group discussion. These whole group discussions ultimately focused on how the school could improve the tasks and scoring rubrics to invite higher quality mathematical work from students from the onset of their efforts.

Lastly, the whole group determined possible next steps including the supports needed to continue building a culture of engaging in high quality mathematics throughout the school. After the protocol, pieces of student work (photos and related task descriptions/scoring tools) that represent the status quo at the school were archived, along with a summary of the discussion, to be used as evidence of growth in this area of school improvement.

Participants & Setting: School

Academy West is a K-8 charter school that has been in existence for approximately 15 years with total student enrollment near 350 students who mostly attend multi-age classrooms. The school strives to be a leader in project-based, real-world learning experiences within a collaborative environment. Within the school, teachers and administrators view student achievement as a three-faceted construct. The first focuses on the mastery of skills and knowledge, visible through deeper understanding of each discipline, the ability to apply learning, thinking critically and communicating clearly. The second facet of achievement centers on developing students' character who are effective learners and ethical people that contribute to a better world. Lastly, the third facet concentrates on producing quality work that demonstrates complexity, craftsmanship, and authenticity (EL Education, 2015).

Participants

The participants in this study were a mix of novice and veteran teachers (n=20) with 20 years as the maximum number of years as a teacher. Additionally, two teacher leaders assisted with facilitating this work one of which was the principal and the other was an instructional coach. The 20 teacher participants included two kindergarten teachers, two first grade, and two sixth grade teachers with the other 14 teachers coming from multi-aged classroom. Specifically, three 2nd/3rd grade teachers, three 4th/5th grade teachers, and five middle school (7th/8th grade) teachers in subject specific roles (science, math, social studies, ELA, and Spanish) participated as well as three other part-time specialist teachers (i.e. visual arts, physical education and a part time 4th/5th mathematics teacher).

Of the 20 teacher participants, over half (n=11) had over ten years of teaching with over five of those years at Academy West. Additionally, all teacher participants reported that they choose to teach at Academy West because of the culture of collaboration and inquiry as well as the focus on project-based learning. Most participants also reported that the environment within the school was challenging, yet rewarding, and they were encouraged and expected to engage in professional conversations on a regular basis.

FINDINGS

Defining Quality Work in Mathematics

Overall, teachers indicated that they were mostly satisfied with the attributes of quality as defined and found them useful in promoting dialogue and creating shared meaning as they examined student work in mathematics. One point multiple teachers brought up in conversations centered on how the quality of students thinking was different from the quality of the product students created, or the aesthetics of the work created. While teachers frequently brought up and discussed attributes that would be associated with the quality of student thinking, there were no indicators concerning "beauty" or the visual organization of the work. Other teachers disagreed, stating that indicators in the craftsmanship section were partly about aesthetics. In particular, "well-crafted mathematics is done with care, precision and accuracy" and thus "requires attention to accuracy and detail" which, to them defined "beautiful mathematics."

Other teachers felt that the aesthetics were less important than the evidence of student thinking, as long as the student work was precise and accurate, and thus no other attributes relating to aesthetics were necessary. Teachers agreed that while the visual displays of thinking they saw in the student work could be clearer, more organized, or more aesthetically pleasing to read, the teachers felt they were potentially hindered by previous protocols that examined final long-term products, where "craftsmanship" was defined through the lens of multiple revisions for aesthetics over time. To these teachers, this meant that when the work is daily or of a more short term product (i.e. weekly work), helping students to organize and clarify their work in a visually pleasing manner was not needed in most cases. Essentially, multiple revisions only for the sake of the aesthetic value, that did not further convey meaning or conceptual understanding, were unnecessary.

Another source of dissonance in the use of the attributes was that some teachers attended to both the important teacher responsibilities in the creation of the tasks and assignments (e.g. the application of mathematics to real life contexts rather than "artificial" school experiences) and to other attributes that centered on decisions made by students (e.g. using a variety of representations, strategies and multiple solution methods). As discussion of the purposes of the protocol ensued, teachers realized they needed to develop a "shared vision of quality work" and identify and differentiate between aspects related to quality that are teachers' responsibility as opposed to students'. Identifying that both teachers and students had specific roles that led to the creation of quality student

work was considered a major "breakthrough" during the discussions. Teachers came to understand that without assignments and tasks that intentionally encouraged the attributes of quality, then students could not be expected to produce quality work.

Making Students' Thinking Visible Through Discourse

Teachers had previously studied the role of discourse in the mathematics classroom and wondered where, if anywhere, this important and powerful tool lived in the attributes of quality student work. As a result of looking at student work, they came to understand that a byproduct of discourse, in particular the written explanations students provided, could be seen in the student work. While not explicitly discourse, students' writing represents a manifestation of their own internal dialogue, which they nurture and develop as they engage in discursive interactions with their peers. Thus, an aspect of discourse, that was represented in their writing, could be evidence of quality work because they had previously engaged in meaningful opportunities talking about mathematics.

Teachers also referenced the attribute of complexity and craftsmanship by recognizing that "the structure and language of mathematics is present in student writing" and that "students use precise mathematical language, appropriate to their grade, in their explanation and discussion." This led the teachers to understand the link between specific connections made during whole-class discourse and the written expression of ideas from this discourse. Essentially, the language of mathematics, and the complexity of it, "could not appropriately be seen in their explanations if they have not previously engaged in numerous rich discussion with others."

Quality Work Represented in Various Models

In considering complexity, the teachers expected to see a variety of representations of mathematical thinking in the student work. Collectively, the teachers wondered if more complex representations would be more appropriate for certain grade levels. This started a discussion that focused on understanding how the progressions of mathematics, and the models of representation used to show conceptual understanding, might be used to judge the complexity of student thinking at any given grade level. Additionally, teachers wondered if student work was more complex, and thus higher quality, if a variety of representations were present or if a student could clearly articulate why their representation was the best for a particular mathematical context. This shows that teachers were attending to the intended connections students were to make to specific grade-level content standards and then the progression of learning across grade levels.

What do Mathematicians do?

Quality work, as defined in these attributes, also embodies using "real work formats and standards from the professional world, rather than artificial school formats" as found in the attributes related to authenticity. In other words, the work should, at least some of the time, represent the real work of mathematicians. This was a source of confusion for teachers because they did not know what mathematicians really do or what would be an "appropriate product of a mathematician's work?" They seemed to understand that incorporating the habits of mind and interaction evident in the Standards of Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010), which they listed as an attribute for authenticity, was part of making the work real for students. However, the teachers ultimately decided that they did not have enough information at the time to fully address this and thus it warranted further study and additional resources to help them answer this question.

DISCUSSION AND IMPLICATIONS

Meaningful opportunities for professional development and time to engage in such experiences are a commodity in short supply. Therefore, leveraging that time in ways that support long-term and school-wide initiatives are critical to the continual growth of the school as well as teachers' classroom practices. In this study, using a quality work protocol focused in mathematics was valuable to help teachers develop a shared understanding of the nature and structure of quality work and had several implications for teacher leaders in designing collaborative work to impact student learning.

First, teachers benefited from structured time to develop a shared understanding of quality work in order to support larger goals of improving pedagogy and student learning. These understandings further supported the overall initiatives within the school and were central to the continued efforts of the teacher leaders within the school. Even though teachers typically spend time looking at student work multiple times a day to provide feedback or design instruction, the use of a structured protocol in a collaborative setting, and time to attend to specific attributes of student work, as in the MQWP, allowed for a different perspective than the everyday solo examination of student work. Creating time for this professional development structure allowed teachers to question potentially ineffective teaching practices, learn new methods, and supported their personal and collective professional growth. Additionally, teachers increased their ability to pay attention to student learning, the attributes of quality work, and to student responses to their tasks and instructional activities, which can improve their instructional decision making process (Little, 2003).

Second, the time spent analyzing this work helped create a strong school-based professional community. For teacher leaders, such experiences are important to changing instructional practice and achieving long-term and school-wide initiatives. Before any conversation about what teachers should be doing, teachers must be considering student thinking which then drives pedagogical practice (Levin, Hammer, Elby, & Coffey, 2013). When teachers' conversations, thinking, and discussions about student learning are at the core of professional development, then teachers are in charge of uncovering and taking on a problem of practice in their own way, coming from their own thinking, not imposed by an external leader. This is important because there is much support for teacher-driven professional development (Bonner, 2006; Garet et al., 2001) where teachers can work together in an environment where they have a common issue to discuss (Zeichner, 2003) and ultimately impacts student motivation, engagement and learning (Colbert, Brown, Choi, & Thomas, 2008). Teachers at Academy West felt empowered to create conditions in their own classroom to improve the quality of student work in mathematics after participating in these experiences in great part because of the leadership at this school. The autonomy and purpose felt by the teachers contributed to the professional community within the school. This kind of professional community sparked interest and engagement to drive the work of teachers and teacher leaders on a daily basis.

For teacher leaders, a teacher-led professional development process such as the one described can positively support school-wide initiatives and goals if proper structures, norms, and tools are in place and available. Using a descriptive protocol was important to the success at Academy West and should be considered by others wishing to focus on similar areas of improvement. What cannot be emphasized enough is that the culture created and nurtured during these professional development experiences were central to the primary intent of the work. Even if the structural elements of effective professional development are in place (Desimone, 2009), a mutually supportive culture is an a priori need.

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APPENDIX A

Attributes Quality Work in Mathematics (adapted from EL Education, 2015)

Complexity
• Complex mathematics is rigorous: the structure and language of mathematics is present in student writing and aspects of the shift, rigor (conceptual understanding, procedural skill and fluency, and application) are present. • Complex mathematics often connects to big concepts and targets the major work of the grade. Or, if the work focuses the supporting work of the grade, it highlights the connection to the major work of the grade. • Complex mathematics supports application of Standards of Mathematical Practice in learning content. • Complex mathematics is expressed by using a variety of representations, strategies and often multiple solution methods. • Complex work may incorporate students' application of higher order math skills through the use of purposeful math tasks and opportunity for math discourse and argument. • Complex mathematics encourages reasoning and problem solving by posing challenging problems that offer opportunities for productive struggle.
Craftsmanship
• Well-crafted mathematics is done with care, precision, and accuracy. Students use precise mathematical language, appropriate to their grade, in their explanation and discussion. • Craftsmanship in mathematics requires attention to accuracy, detail, and making use of the structure and language of mathematics. • Craftsmanship in mathematics requires students to explain and justify work and provides feedback that helps students revise initial work, especially in their explanations and justifications.
Authenticity
• Authentic work demonstrates the original thinking of students rather than simply showing that students can follow directions or fill in the blanks. • Authentic mathematics often uses real work formats and standards from the professional world, rather than artificial school formats (e.g., students create a report for a local environmental agency rather than a worksheet for the teacher). • Authentic work often connects academic standards with real-world issues, controversies, and local people and places. • Authenticity gives purpose to work; the work matters to students and ideally to a larger community as well. When possible, it is created for and shared with an audience beyond the classroom. • Authentic work demonstrates habits of mathematicians present in the Standards for Mathematical Practice.

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