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INCREASING COLLECTIVE ARGUMENTATION IN THE MATH CLASSROOM THROUGH SUSTAINED PROFESSIONAL DEVELOPMENT

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We share the case of one teacher engaged in professional development (PD) designed to improve collective argumentation. We present an analysis of two lessons in her classroom, one before and one after her engagement with the professional development. Findings show that the classrooms differ across both teacher support for collective argumentation (requesting ideas and elaboration vs. requesting facts and methods), and student contributions (justifications vs. procedures and facts).

Keywords: Teacher Education-Inservice/Professional Development, Instructional Activities and Practices, Classroom Discourse, Reasoning and Proof

Objective

In this paper, we explore the change in one teacher's classroom after participating in a professional development (PD), Mathematics *Studio PD* (Foreman, 2013), designed to improve collective argumentation in the classroom. More specifically we examine the question: "How does engagement in *Mathematics Studio PD* play out in one individual teacher's classroom?"

Background and Theoretical Framing

We leverage frameworks related to contributions from students and supportive questions and actions from teachers for collective argumentation to make sense of the totality of a lesson. The PD is designed to address these constructs using mathematically productive habits and routines. We begin by describing the underlying principles of the PD and describe each construct.

Underlying Principles of the *Studio PD*

The *Studio* PD advocates for student-centered classrooms where all students engage in and contribute to discourse that focuses on mathematical sense making, justifying, and generalizing mathematical ideas. A constructivist theory of learning (Von Glasersfeld, 1995) underlies these tenants where students are meant to engage in cognitively demanding tasks (Smith & Stein, 1998) providing opportunities for productive disequilibrium leading to deep mathematical learning. All students are viewed as capable mathematical thinkers with the PD's focus on growth mindset (Dweck, 2007). In this way, mathematics is not treated as a set of rules, but rather as an interconnected and logical structure (Hiebert, 1986) and the authority lies within the mathematics rather than the teacher or the textbook.

Teacher Support of Collective Argumentation.

Teachers support such mathematics by orchestrating the classroom discussion towards collective argumentation focused on justification and generalization. We use the construct of collective argumentation to describe discussions which "involve[s] multiple people arriving at a conclusion, often by consensus." (Conner, Singletary, Smith, Wagner, & Francisco, 2014, p. 401). Teachers facilitate collective argumentation through their questions (requests of action or information) and other supportive actions (directing, promoting, evaluating, informing, and repeating). The quality of these questions and support impacts the students' contributions to collective argumentation occurring in the classroom.

Contributions Types

We use the term contribution to define statements made by the students in support of collective argumentation. In the PD, student contributions are categorized into *procedures and facts (PF), justifying (J),* and *generalizing (G)* (Foreman, 2013) (see Figure 1 for a description of each category). To engage in meaningful mathematical discourse contributions should include justifications and/or generalizations.

PF USING PROCEDURES/FACTS	J JUSTIFYING	G GENERALIZING
No evidence of reasoning • Short answer to a direct question • Restating facts/statements/rules • Showing or asking for procedures *Uses meanings, definitions, properties, known math ideas to describe reasoning when:* • Explaining ideas & methods • Questioning to clarify • Noticing relationships/connections But ***doesn't show why*** the ideas/methods work	*Reasons with meanings of ideas, definitions, math properties, established generalizations to:* • Show why an idea/solution is true • Refute the validity of an idea • Give mathematical defense for an idea that was challenged	*Reasons with math properties, definitions, meanings of ideas, established generalizations, and mathematical relationships as the basis for:* • Making conjectures about what might happen in the general or special cases or • Justifying a conjecture about what will happen in the general or special cases

Figure 1. Contribution types.

Methods

The setting for this study is an elementary school in a mid-sized school district in the Pacific Northwest. This school has an enrollment of approximately 580 students with a 73% minority enrollment and 79% of children enrolled in free and reduced lunch. At this school 53% of 5th graders were meeting the math standards. The school is participating in a 3-year district-wide professional development program focused on improving instruction in mathematics. This PD uses the *Studio Model* of PD combined with summer workshops on best practices for teaching mathematics (Foreman 2013). Data collected includes 2 lessons videotaped at the end of each year, starting with a baseline video (Year 0) before engagement with PD as well as after the completion of each full year of the PD (Years, 1, 2, and 3). In addition, researchers observed and video recorded each PD session and took detailed field notes.

For this study, we focus on one fourth-grade teacher (Hannah – all names are pseudonyms) and analyze two lessons, one from before her engaging with the PD (Year 0) and one after (Year 3). We highlight the changes in her classroom and share some of Hannah's reflections throughout the PD to give insight into her engagement with the PD. Hannah was a participating teacher in the PD in Year 1, and the studio teacher in Years 2 and 3. Each lesson analyzed was transcribed and watched by two researchers multiple times.

To code student contributions and support for collective argumentation, talk turns supporting or contributing to collective argumentation were identified in the transcript. Each talk turn was coded as a direct contribution or question/supportive action. Direct contributions were coded as *procedures and facts, justification,* or *generalization* (see Figure 1). For example, a student working on the claim that 24/42 > ½ stated, "she divided 42 divided by two and she got 21. And since 24 is greater than 21, than it's over- the half. It's greater than half." This statement was coded as a justification as the student was "reasoning with meanings... of math properties" (Figure 1). Questions and other supportive actions were coded with the framework in Table 1. For example, the teacher asking a student "How do you write ten cents?" was coded as *requesting a factual answer* as the request only included a how. The teacher question "Why does it work mathematically?" was coded as *requesting elaboration* as it requested the student to elaborate further on their response, justifying their answer using mathematical reasoning. For supportive actions, a talk turn including the teacher statement "OK guys, let's see if they fixed it in the right way," was coded as *evaluating* as it centered on the correctness of the mathematics.

Results & Discussion

Hannah's lessons in Year 0 and Year 3 differed across the constructs listed above. Next, we discuss these observed changes and connect them to Hannah's statements throughout the PD, illustrating her intentional engagement with the PD.

Collective Argumentation.

From Year 0 to Year 3 a shift occurred in terms of *teacher questions* and *supportive actions*, captured by the collective argumentation framework (Conner et al. 2014). In Year 0 most teacher questions focused on requesting facts (58%) or methods (21%). In Year 3 most of the teacher questions focused on requesting ideas (24%) or elaborations (58%) (see Table 1). In terms of *teacher supportive actions,* promoting actions increased (1% to 30%) while evaluating actions decreased (32% to 4%). Additionally, we saw an increase in informing actions (20% to 26%) and a decrease in repeating actions (24% to 5%) (see Table 1).

Table 1. Categorization of Teacher Questions and Teacher Supportive Actions

Teacher Questions			Teacher Supportive Actions		
	Year 0	Year 3		Year 0	Year 3
Requesting Fact	58%	3%	Directing Action	23%	35%
Requesting an Idea	4%	24%	Promoting Action	1%	30%
Requesting a Method	21%	8%	Evaluating Action	32%	4%
Requesting Elaboration	12%	58%	Informing Action	20%	26%
Requesting Evaluation	5%	7%	Repeating Action	24%	5%

The change in focus is correlated with changes in the quality of student contributions. In Year 0 most of those contributions were categorized as procedures and facts (96%) while in Year 3 42% were categorized as justification (see Table 2).

One of the foci of the PD is on questioning to research children's mathematical thinking so the teacher can build on their understanding. At the beginning of her engagement with the PD, Hannah's questioning did not model this focus. In the initial year she began as the studio teacher (Year 2, Studio 1) she reflected on questioning, stating the realization that "The questions are [asked] to give you [the teacher] ideas where they [the students] are at and not to teach them. That is something I never thought of." In Year 2, Studio 3 Hannah responded to the prompt *What are key elements of your professional learning from today's collaborative inquiry?* Her response included "Plan on asking specific questions during conferring [with the students] – research first and then advance their thinking." In Year 3, Studio 2 Hannah responded to the prompt *What is it that you know about the HOM now that you didn't know at the beginning of studio?* Hannah responded, "Pushing students to show their thinking rather than just having a correct answer." Additionally, she shared that she "found it interesting because I started to use more visuals when I started training with the math studio model. Math Studio really brought more of the visual, justifying with the visual."

Table 2. Categorization of Contributions from students (columns represent 100%)

Contributions	Year 0	Year 3
P/F	96%	58%
Justification	4%	42%
Generalization	0%	0%

Conclusions/Take-Away

In the context of this three-year PD, Hannah made significant changes, bringing her teaching in line with the goals and philosophy of the PD. Throughout the PD, Hannah's reflections, goals for next steps, and remarks made during the studio days captured her intentional implementation of this PD. These comments align with observed changes from Year 0 to Year 3. The focus in the classroom shifted from mostly focusing on procedures and facts to including justifications. Students were credited with (re)inventing mathematics and student strategies were shared with the class. Being able to justify was the ultimate authority. This change is exemplified in the following excerpt from the Year 3 lesson analyzed for this paper.

Hannah: How do you know that this is right?
Student: Because I am smart
Hannah: That is not math reasoning. Math reasoning is the authority in this classroom. *I am smart* does not tell me anything. *I am smart* tells me that you think too much of yourself. So mathematically why does this make sense? And what strategy did you use to solve it?
Hannah: [to S's partner] you hold him accountable to explain to you.

These changes in Hannah's teaching practices and in her students and their contributions are an inspiring example of changes that can occur in a long-term PD. Her example of growth illustrates the many strengths of this PD and informs teacher educators, PD providers, and school administration and leadership of the potential benefits of a PD of this nature.

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