DOWN THE ROAD: TEACHER'S PERCEPTIONS AND UPTAKE OF PD AFTER SEVERAL YEARS

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This study captured middle and high school teachers' perceptions of what they learned from professional development 3-4 years after participating in one of three NSF funded year-long professional development (PD) projects. We surveyed teachers (n=66) from three different PD projects on the types of content, pedagogy, and resources that they remembered learning and continue to use when teaching mathematics. Results indicate that teachers remember and use many aspects from PD experiences 3-4 years down the road especially those they find relevant to their current teaching position. Most residual learnings from PD also appear to be highly aligned with the goals and intentions of the PD developers and researchers and these learnings have evolved through colleague collaboration and other PD opportunities.

INTRODUCTION

One central challenge for the field of teacher professional development (PD) is how to design interventions that target teacher knowledge, while also maintaining a focus on instructional practice and student learning (Jacobs, Koellner, Seago, Garnier & Wang, 2020). A number of researchers have worked to address this challenge and there is now a strong research base delineating critical design features of effective PD (e.g., Borko, Jacobs & Koellner, 2010). The consensus in the current PD discourse about features of effective PD include a focus on mathematics content, student learning of content, active learning opportunities for teachers, coherence, duration, and collective participation (Sztajn, Borko, & Smith, 2017). Although some PD programs that adhere to design recommendations by the literature have produced encouraging results (e.g. Franke, Carpenter, Levi & Fennema, 2001), others have proven less successful (e.g. Jacob, Hill & Corey, 2017).

It is not clear why there have been mixed results from rigorous empirical studies of PD incorporating these design recommendation that contradict conventional wisdom among the field. There are many reasons that potentially could account for these varying results such as: the content of the specific programs evaluated may have been inefficacious, fidelity to the materials or pedagogical practices may have deviated from the identified goals and practices, difficulties may have resulted from scaling the program to multiple sites with different facilitators, or issues may have arisen with the research design and methodology. An alternate perspective is most, if not all, of the impact studies that have been funded recently have been large-scale quantitative studies. Many have shown incremental change in teacher knowledge and practice one year following the intervention (Murata et al., 2012). This need for clarity may rest in

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an often-ignored issue related to the time allowed for funded projects to study the impact of PD on teachers and students. Many large randomized controlled designed studies look at pre post data across one year and at most, use a post-post measure one year out. We hypothesize this is not enough time to measure PD impact. We argue that for teachers incorporate new ideas and then to plan, implement, reflect and modify instruction may require more time to be reflected in practice and in research results than the typical one-year that is often related to funding cycles.

The Taking a Deep Dive (TaDD) research study examines the residual impacts of three different professional development models on teacher learning, specifically 3-4 years after the actual PD experiences. The project is conducting a rigorous cross case analysis across participants from the different projects across the US. This paper is focused on a survey that was given to participants in May 2019 which was 3-4 years after their PD experience. Although this study focuses on self-report survey data, findings contribute to the PD landscape of PD design and survey design. Findings identify indicators that seem to provide evidence of why some teachers might learn and implement more from a given PD compared to another (others). Our analysis also elucidates how a carefully designed survey focused on the constructs of content, resources, and pedagogy tell an important story related to the similarities and differences of the PD and some potential limitations.

THEORETICAL FRAMEWORK

PD models fall on a continuum from adaptive to specified (Borko, Koellner, Jacobs & Seago, 2011). On one end of the continuum are *adaptive* models, in which the learning goals and resources are derived from the local context and shared artefacts are generally from the classrooms of the participating teachers. In these models, the artefact is selected and sequenced by the facilitator and/or the participating teachers, and the related activities are based on general guidelines that take into account the perceived needs and interests of the group. On the other, specified models of PD typically incorporate published materials that specify in advance teacher learning goals and provide resources and guides to implement the PD. In video-based specified PD, the video clips are typically pre-selected and come from other teachers' classrooms.

The nature of what teachers take up and use across the continuum has the potential to shed light on factors that are associated with the teacher learning related to content and pedagogy. This study examines three professional developments that fall on different parts of the continuum. The goal is not to determine which types of PD are "best" because each has its affordances and challenges, but rather to better understand the *variance* of teacher uptake and use (in their classroom contexts) within and across these PD experiences. Understanding and unpacking variance among and between types of PD offers the potential to identify the factors that impact uptake and use from PD. This paper examines how teachers' self-reported uptake differs across PDs located at different points on the adaptive-specified continuum. Specifically, one is highly adaptive, one is highly specified, and one lands in the middle. We believe conducting

a cross-case comparison aids in helping us understand the factors associated with uptake related to content, pedagogy, and resources.

OVERVIEW OF TaDD PROJECT

This three-year impact study, *Taking a Deep Dive* (TaDD), collects qualitative data from three large U.S. National Science Foundation PD projects in order to use cross case analysis to further inform what teachers take up in their classrooms 3-4 years after the initial professional development experiences. We want to explore how certain PDs get applied in specific educational contexts in different geographical locations. This paper uses a comparative case analysis and focuses on the portion of the TaDD study that investigates self-reported learning related to pedagogy, content and resources taken up and used from the following three NSF PD projects one to two years after the project and funding ended. In the next section, we briefly describe the three different PD projects.

Learning and Teaching Geometry (LTG) LTG is an efficacy study of the learning and teaching geometry professional development materials: Examining impact and context-based adaptations, sought to improve teacher's own knowledge and instructional strategies in transformations-based geometry. This PD consists of 54 hours of highly specified video-based PD grounded in modules of dynamic transformations-based geometry which is aligned with the Common Core State Standards in mathematics (CCSSM). Through video analysis, teachers work together to solve problems and further their knowledge in mathematics teaching in geometry. The PD allows teachers to better support students in their attempt to gain a deeper understanding of transformations-based geometry through activities like rate of change on a graph, scaling activities, and similarity tools to name a few. LTG is a specified PD as the content and pedagogical goals of the PD are clearly articulated for each workshop.

Collaborative research TRUmath and Lesson Study (LS) is a project that supports fundamental and sustainable improvement in high school mathematics teaching. LS is aimed to engage in design research to develop and implement a replicable model of teaching for a coherent, department-wide approach. In the PD, teachers collaboratively created focused and coherent lesson plans from their curriculum aimed at providing students the opportunity to gain a deep understanding of mathematics and the ability to make connections. The PD took a unique twist on lesson study by using the TruMath framework as a common observation tool that could guide teacher noticing and anchor discussions related to the lab lessons. The lab lessons are one teacher volunteers to teach a lesson and other participants in the LS observe quietly in the back of the classroom. The *TruMath* framework focused discussion and analysis of classroom interactions across five dimensions. Teacher teams identified a goal from one of the dimensions of the framework that they wanted to focus more deeply on. LS is an adaptive form of PD that utilized the TRU framework but allowed for teachers' ideas to guide the workshops.

Visual Access to Mathematics: Professional development for teachers of English Learners (VAM). The VAM PD, the focus PD of this paper, is a "60-hour blended, face to face and online course to build teachers' knowledge of and self-efficacy about LRT strategies to strengthen English Learners (Els) problem solving and discourse in middle grades" (De Piper et al., 2021 p. 491). The goals and intentions of VAM were to cultivate in teachers the fluent use of representations, anticipation of students' strategies, the ability to interpret and construct various mathematical solutions, and to reason with and across representations. Teachers learned how to strategically select and align VRs with their instructional goals, anticipate student thinking and misconceptions, and then implement lessons using these strategies in their classrooms. Once implemented they would share experiences and student work, and collaboratively and independently reflect on the teaching cycle in the VAM PD online workshops. VAM falls in the middle of the adaptive-specified framework as the face-to-face workshops had specified and intentional goals, and the online professional learning meetings were guided by the teachers using artefacts of practice to guide their discussions.

METHODOLOGY AND METHODS

Sixty-six participants took a 32-question survey (28 LTG, 25 VAM and 13 LS). Teachers also provided background information. All teachers held an undergraduate degree and 88% held a graduate degree, on average, but larger proportions of LTG (93%) and VAM (96%) teachers held graduate degrees compared to LS teachers (62%; $t=3.29$, $p<.01$). In addition, VAM teachers reported over 16 years of experience teaching, significantly more than LS and LTG teachers who reported approximately 10 and 12 years, respectively ($t=2.81$, $p<.05$ and $t=2.57$, $p<.05$, respectively). On average, 15% of teachers were currently teaching Geometry with no differences between groups.

The survey included both closed and open-ended questions that asked participants to reflect on their PD experience and characterize their past and/or current use of the PD content, pedagogy and materials as well as the support they received to implement new content and instructional practices. The survey included seven Likert scale questions. Participants responded to statements on a scale of 1-10, as well as eighteen follow up questions that allowed the participants to provide more details about their responses.

We coded the 18 questions on the survey from all 66 participants. We created a coding manual starting with apriori codes. The apriori codes were aspects of effective professional development from the literature (e.g. analysing student thinking, specific content, and representations used), supporting diverse learners. We then included emergent codes that appeared frequently and appeared relevant to the programs. We began with three researchers coding one survey from each project. We came together to discuss codes, add codes to the manual, and reconcile differences. We then continued this process with seven surveys from each project to achieve inter-rater agreement at 91%.

Once all surveys were coded, we calculated the amount of time a participant mentioned each code in their survey responses. For each of the four domains, we identified and averaged the specific codes included within that domain. For instance, we identified four codes that were related to content; these codes included GCSL (general content student learning), GCTL (general content teacher learning), SCSL(specific content student learning), and SCTL(specific content teacher learning). SCSL would refer to a comment on the survey that indicated specific content (e.g. dilations) and discussed a focus on student learning. Then we identified three codes related to pedagogy; these codes include MS (multiple solution strategies), SSDL(student strategies for diverse learners), and ST (student thinking). We identified six codes that were related to resources; these codes included GR (general resources), RSDL (resource to support diverse learners), RTL (resource for teacher learning), SR (student resource), TSML (technology support math learning), and V (mention of video to support noticing). Lastly, we identified four codes related to support; these codes include C (collaboration), FI (facilitator impact), CS (coach support), and PS (principal support). Finally, percentages of comments were created from the four domain averages and percentages of comments of the individual codes within domains were calculated for a deeper understanding of teacher responses.

ANALYSES

To analyse the data, we used descriptive statistics, paired samples t-tests, and analyses of variance and covariance with pairwise comparisons using the Bonferroni test to identify and understand the differences and similarities between uptake by project (LS, LTG, VAM). To control for pre-existing differences, graduate degree and years of experience teaching were included as covariates in the analyses of covariance. Measures of teacher undergraduate and graduate degrees and currently teaching geometry were included in preliminary analyses but found to be non-significant and dropped from subsequent analyses.

RESULTS

To identify what teachers remembered from their PD experiences 3 to 4 years ago and what they have continued to use related to that PD, we analysed the average percentages of comments made by teachers. Table 1 presents the percentages of comments within domains and across projects and the results of the analyses of covariance adjusted for teacher years of experience teaching.

Types of comments within projects. Within projects, paired samples comparisons within the LS group identified a significantly larger percent of comments focused on support compared to content ($t=6.70$, $p<.001$), pedagogy ($t=4.76$, $p<.001$), and resources ($t=4.62$, $p<.01$). While this group also commented more on resources than on content ($t=3.38$, $p<.01$), both LTG and VAM emphasized resources more than all other domains: content ($t=2.86$, $p<.01$ and $t=14.21$, $p<.001$, respectively), pedagogy ($t=10.70$, $p<.001$ and $t=17.89$, $p<.001$, respectively), and support ($t=4.14$, $p<.001$ and $t=12.82$, $p<.001$, respectively). LTG and VAM also focused more on content ($t=9.90$,

p<.001 and t=3.80, p<.01, respectively) and support (t=8.29, p<.001 and t=9.48, p<.001, respectively) than on pedagogy.

To summarize, although the domain resources was somewhat emphasized in the LS project, content and pedagogy were emphasized far less. The LTG project, a specified PD, had the largest percentage of comments that were distributed among the categories. The largest percentage was related to resources and then percentages were fairly evenly distributed between content and support, but less so for pedagogy. The VAM teachers mostly emphasized resources followed by support and content and pedagogy.

Types of comments across projects. Comparing teacher comments across projects, results of the analyses of covariance identified distinct patterns of comments about PD experiences for each group (see Table 3). LS participants were significantly more likely to mention support and pedagogy compared to both the LTG (t=7.81, p<.001 and t=3.71, p<.01, respectively) and VAM participants (t=8.28, p<.001 and t=3.17, p<.01, respectively). Their comments included principal and coach support as well as colleague support. Support was the domain qualitatively discussed most throughout the survey.

LTG participants emphasized content significantly more than both LS (t=5.51, p<.001) and VAM participants (t=6.22, p<.001) and resources more than LS participants (t=4.35, p<.001). On the other hand, VAM participants mostly emphasized resources and did so significantly more than both LS (t=8.55, p<.001) and LTG participants (t=5.62, p<.001).

Domains of teacher comments	Lesson Study PD (LS, n=13)	LTG PD Efficacy Study (LTG, n=28)	Visual Access for ELLs in Math PD (VAM, n=25)	F	Pairwise comparisons
Content	10%	29%	10%	25.76***	LTG>LS*** LTG>VAM***
Pedagogy	13%	3%	4%	7.34**	LS>LTG** LS>VAM**
Resources	23%	43%	65%	37.56***	LTG>LS*** VAM>LS*** VAM>LTG***
Support	54%	25%	21%	38.89***	LS>LTG*** LS>VAM***

Total	100%	100%	100%

Note. Results from ANCOVA adjusted for years of experience teaching.
**p < .01; ***p < .001.

Table 1: Results of ANCOVA on percent of teacher comments across the four domain averages, by project (N=66)

Results indicate that the teachers' perceived uptake after 3-4 years was highly related to the goals and intentions of the PD projects. As the PD projects' goals and intentions were identified at different points on the adaptive – specified continuum, differences were highlighted based on comments related to content, pedagogy, resources, and support. In some ways this is not surprising that the different PD programs had different emphases, and these were revealed in the clusters of codes related to content, pedagogy, use of resources, and support yet it provides promising evidence that PD learning held residual value.

DISCUSSION

This study reveals that the teachers that participated in the three NSF funded PDs, 3-4 years before taking this survey, highlighted and wrote about the main goals and intentions of the PD that they attended. Although this may not be surprising that the teachers remember what the facilitator and PD developers intended, it shows promise that the PD's yielded high residue of teacher learning 3-4 years after the PD workshops especially when the content and the pedagogy of the PD were relevant, useable, and transferrable across the daily lessons of the teachers.

The LS teachers generally tended not to emphasize content, and when they did, they mostly discussed aspects of content that were generally related to teacher or student learning. In fact, they mentioned teacher learning more than VAM ($t=3.06$, $p<.01$) and student learning more than LTG ($t=2.50$, $p<.05$). When discussing pedagogy, most comments were related to working with diverse learners. If they were discussing a resource, they typically were discussing a specific resource, and did so more often than LTG ($t=3.71$, $p<.001$). Most likely, the specific resource they discussed was the TRU framework which was the centre piece of this project. LS teachers were significantly more likely to discuss specific resources. When talking about support, they mostly emphasized support from colleagues and more so than VAM ($t=2.71$, $p<.05$). Although only 21% of their comments were about coach support, this percentage was still significantly larger than for LTG ($t=3.05$, $p<.05$) and VAM ($t=3.09$, $p<.01$).

The LTG project, the most specified PD, had the most distribution between the four categories. Resources, both general and specific, were provided to participants including rich tasks, videotapes and applets to support the implementation of transformations-based geometry in middle and high school classrooms. LTG teachers commented specifically on the geometry content they learned and used in their classrooms which is not surprising since the PD was specified and the content new to many participants.

The VAM PD, is also a specified PD but the specificity did not only lie in the content but in the strategies, specifically using representations, to support emergent bilinguals. The VAM teachers commented on resources more than the other areas - content, pedagogy and support, and commented on resources more than teachers in the LS and the LTG PDs. The LTG and VAM projects did not solicit support from principals and coaches and these categories of support were not mentioned often by either group, but they did discuss the support they received from their colleagues and from the facilitators during the PD experience.

This study has a small sample size and results need to be taken with caution. The findings do provide some evidence that teachers remember and use aspects from a PD that they participated overtime and that there is residual knowledge that has endured. More research is needed to understand teacher learning over longer periods of time and perhaps to increase funding cycles for this to happen. Our next steps are to continue in this line of inquiry by conducting the cross case analyses from these projects. We will analyse how classroom practices related to the goals and intentions of the PD project are reflected in their teaching. We will conduct think aloud protocol interviews to understand teacher learning more fully and how this learning is evidenced in daily classroom practice through their voices.

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