Teaching and Teacher Education 72 (2018) 107–121

Contents lists available at ScienceDirect

Teaching and Teacher Education

journal homepage: www.elsevier.com/locate/tate

Investigating relationships between school context, teacher professional development, teaching practices, and student achievement in response to a nationwide science reform

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HIGHLIGHTS

- Evaluation of a large-scale, top-down, national curriculum and examination reform.
- Highly valid high-stakes student performance measure.
- Analysis of school-, teacher-, teaching-, and student-level variables.
- Teacher professional development can influence classroom instruction.
- Weak association of some aspects of classroom instruction with student performance.

ARTICLE INFO

Article history:
Received 28 August 2017
Received in revised form
11 December 2017
Accepted 22 February 2018

Keywords:
Science education
Curriculum reform
Professional development
Instructional practice
High-stakes testing
Advanced placement

ABSTRACT

Situated in the context of the Advanced Placement curriculum reform in the sciences, this quantitative study validates selected elements of Desimone's (2009) conceptual framework on teacher professional development. Using national data sets with data from 133 336 students and 7434 teachers, multi-level structural equation models indicate that professional development participation and contextual school- and teacher-level factors influence teachers' classroom practices. In turn, aspects of instructional enactments characteristics are significantly, but very weakly, associated with student performance. Thus, this study reinforces calls to provide teachers opportunities for high-quality professional development and suggests to advance research that identifies effective instructional practices.

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https://doi.org/10.1016/j.tate.2018.02.011
0742-051X/

1. Introduction

In times of changing curricular standards induced through large-scale curricular reforms such as the Common Core State Standards Initiative (2010a, 2010b) or the Next Generation Science Standards (NGSS; NGSS Lead States, 2013), it is critical to prepare teachers for the challenge to adequately align their teaching to new educational landscapes. Desimone's (2009) logic model for studying the effects of professional development (PD) suggests that teachers' PD participation is associated with knowledge and skill gains that relate to changes in instructional practice, which in turn lead to increased student learning and achievement. While this conceptual framework is widely accepted and adopted in the field, validation studies indicate mixed empirical evidence and call for more research to better understand how teacher PD translates into effective practice (Desimone & Garet, 2015). This study responds to this call for research by examining how teachers adapt to the redesign of the Advanced Placement (AP) science program from a perspective of Desimone's (2009) framework.

College Board, the provider of the AP examinations, responded to the recommendations of the National Research Council (2002) and revised the AP program in an attempt to increase student learning and preparation for study beyond high school. The AP program provides opportunities for high school students to engage in rigorous, college-level courses in a broad range of subject areas. Students often regard AP examinations as high-stakes because of perceived benefits for college admission and the potential to count passing scores toward college credit or placement in more advanced disciplinary courses. The revised AP curriculum reduces its former emphasis on broad content coverage and prescribed algorithmic procedures. In turn, the emphasis on scientific practices, critical thinking, inquiry, and depth of understanding of science concepts is increased. These changes are in line with the Framework for K-12 Science Education (National Research Council, 2012a) and the NGSS (NGSS Lead States, 2013). Teachers have strong incentives to engage in PD activities to align their instruction with the new AP program in order to properly prepare their students for the revised AP examinations. Hence, this large-scale, top-down, nationwide curriculum reform constitutes an excellent opportunity to contribute to the in-service secondary science teacher education research base and to validate selected elements of Desimone's (2009) framework for studying the effects of PD. In particular, this study analyzes associations of teachers' PD participation with teachers' instruction, as well as associations of teachers' instruction with student achievement, situated in the corresponding local contexts.

2. Conceptual framework

2.1. Importance and impact of PD participation

As described in Desimone's (2009) framework, the most direct outcomes of teachers' participation in effective PD activities are increases in teacher knowledge and changes in teachers' beliefs which might indirectly enable teachers to modify their classroom instruction.

Characteristics of effective PD activities. In past decades many studies evaluated the impact of professional learning activities to discern characteristics of effective PD for teachers. Desimone (2009) summarizes this research base and identifies active learning, coherence, content focus, collective participation, and duration as core features of high-quality PD. Active learning refers to PD that affords opportunities for teachers to actively contribute to the knowledge and skills building process through activities such as interactive feedback on teaching demonstrations or review of student work. Coherence refers to PD that is connected to existing curriculum implementations, standards, and policies, as well as teachers' prior knowledge, skills, and beliefs. Content focus refers to PD that increases teachers' expertise related to different knowledge domains of teaching. Collective participation refers to affordances of PD activities that enable participation from teachers in similar local contexts such as teachers from the same grade-level, disciplinary concentration, or school. Duration refers to both the total contact time and frequency of teachers' interactions with the PD environment. Notably, this list of design features is similar to other lists of characteristics that constitute high-quality PD. For instance, Borko, Jacobs, and Koellner (2010) emphasized the importance for PD design to situate content in practice, focus on student learning, model teaching practices, afford active learning, help create collaborative professional learning communities, align goals to school settings, and provide on-going and sustainable learning opportunities. Similarly, Darling-Hammond, Hyler, and Gardner (2017) highlighted that the design of effective PD includes a focus on content, incorporation of active learning, support of collaboration, use of models of effective practice, opportunities for coaching and expert support, offers for feedback and reflection, and a sustained duration. Nevertheless, design features of PD activities only represent one aspect that might contribute to effective PD participation. For instance, Kennedy's (2016) review of 28 studies on the influence of PD on instructional practices concluded that PD effectiveness highly varies, even for PD with similar design characteristics. Kennedy (2016) indicated that PD effectiveness also depends on factors such as the PD program's underlying pedagogy to promote teacher learning. Other influences on PD effectiveness might include teachers' attitudes and beliefs with respect to PD, teachers' micro-level interactions during their PD engagement, and contextual school-level factors (Desimone & Garet, 2015; Fore, Feldhaus, Sorge, Agarwal, & Varahramyan, 2015; Kennedy, 2016).

Influence of PD participation on teachers' knowledge and instruction. Numerous research studies indicate that participation in PD that has a focus on content, provides coherent learning experiences, models instructional enactments, affords collective participation, or has high duration are associated with increases in teacher knowledge (e.g., Allen & Penuel, 2015; Fishman et al., 2013; Garet, Porter, Desimone, Birman, & Yoon, 2001; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Roth et al., 2011). Besides more formal PD activities, teacher participation in collaborative learning activities that include coaching or peer-mentoring components also possess potential to increase teachers' knowledge and skills (e.g., Bowe & Gore, 2017; Kyndt, Gijbels, Grosemans, & Donche, 2016).

Studies that explored direct associations of teachers' PD participation on the enactment of instructional practices found that PD that focuses on content, provides opportunities for collaborative or collective participation, ensures coherence with local contexts, includes active learning, or offers sustained and frequent exposure to professional learning lead to changes in teachers' classroom instruction (e.g., ; D. K. Cohen & Hill, 2000; Correnti, 2007; Fishman et al., 2013; Garet et al., 2001; Jeanpierre, Oberhauser, & Freeman, 2005; Matsumura, Garnier, & Resnick, 2010; Penuel et al., 2007; Roth et al., 2011).

2.2. Factors related to student learning

At the heart of every curriculum reform and PD activity is the desire to ultimately advance student learning. However, as indicated in Desimone's (2009) framework, relationships of PD participation and student achievement are indirect and mediated by teachers' knowledge and instructional practices. Teachers' classroom instruction can be seen as the most direct teacher-level influence on student learning. Besides teacher-level factors,