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Bolstering the Impact of Online Professional Development for Teachers

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Abstract

Online professional development (OPD) for teachers is an increasingly popular and viable alternative to face-to-face professional development. While OPD can be effective, little is known about OPD's design and implementation features that maximize its impact. Using data from a large-scale OPD initiative, this correlational study (N = 1231) investigates antecedents of self-reported changes in teacher knowledge, classroom practice, and student achievement. Three regression analyses replicate the importance of several factors in effective professional development, or online learning more generally, and also identify additional predictors of OPD's impact(s). The paper also discusses an applied framework for conceptualizing and modeling the effects of OPD's features on its successive outcomes. Implications for the design, implementation and evaluation of OPD, directions for future research, and study limitations are discussed.

Keywords: online professional development, effectiveness, teacher quality, online learning

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Introduction

Recently, online professional development (OPD) has proliferated in an effort to eliminate various barriers to face-to-face professional development, e.g. access and scheduling. However, since OPD is a recent innovation (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009), those hoping to design and implement it have available little in the way of objective, research-based knowledge to guide their efforts. Indeed, there is a paucity of research conducted systematically to learn how to bolster OPD's impact on teachers and students (Ginsberg, Gray, & Levin, 2004; O'Dwyer et al., 2010). Instead, the bulk of the literature around OPD is more anecdotal or suggestive than it is empirically based (Whitehouse, Breit, McCloskey, Ketelhut, & Dede, 2006).

In their recent research agenda for OPD, Dede et al. (2009) discussed the problems associated with the current state of the OPD literature:

> Until more rigorous [online teacher professional development] research is conducted, developers are hard pressed to know the best design features to include, educators remain uninformed about which programs will help support teacher change and student learning, and funders lack sufficient guidelines for where to direct their support (p. 8).

Hence, this present study addressed the research question of how to increase the impact of OPD. More specifically, we attempt to link particular OPD design and implementation features to OPD's impact on teachers' knowledge, classroom practices, and their students' achievement. Such research-based knowledge can be incorporated into the design and implementation of future OPD programs for teachers and can also provide more of an empirical basis for the training of OPD facilitators (Russell, Kleiman, Carey, & Douglas, 2009).

Conceptual Framework and Literature Review

Desimone's (2009) conceptual framework for professional development activities contends that:

- Professional development activities change participants' knowledge and skills and/or attitudes or beliefs.
- Participants implement the new knowledge, skills, attitudes or beliefs to improve classroom practice.
- Instructional change in turn fosters increased student achievement.

During professional development impact studies, Desimone recommends measuring these intermediate and ultimate outcomes, and also advises identifying variables that mediate and moderate such effects. With this study, we focus on three such outcomes, and also attempt to understand OPD factors that might hinder or promote these effects.

Our study draws primarily on two extant bodies of research, namely the literatures on the effectiveness of face-to-face professional development and online learning. These two bodies of relevant literature both frame our study and provide a context for the interpretation of the findings. Regarding the effectiveness of professional development, Desimone's (2009) recent

review of the literature showed that effective professional development is characterized by: (a) a focus on subject matter content, (b) extended duration, (c) coherence, (d) opportunities for active learning, and (e) collective participation.

Lessons about OPD can also be learned from the broader online learning effectiveness literature. Earlier meta-analyses and literature reviews in this field have highlighted the importance of, for example: instructor involvement, interaction among participants, participants' computer proficiency, time on task, learner activity and reflection, and feedback from the instructor (Zhao, Lei, Yan, Lai, & Tan, 2005; Tallent-Runnels et al., 2006; Means, Toyama, Murphy, Bakia, & Jones, 2009).

In contrast to the professional development and online learning effectiveness literatures, various scholars have noted a dearth of empirical research that could be utilized to design and implement effective OPD for teachers (e.g., Russell et al., 2009). The field has learned through rigorous experimental research, however, that OPD can be effective. Across four randomized controlled trials in different grades/subjects, O'Dwyer et al. (2010) found medium-to-large OPD effects on teacher knowledge and instructional practices as well as some small effects on short-range student outcomes.

To our knowledge, there are only two published studies that examined the impact of specific design/implementation features on OPD's effectiveness. First, Carey, Kleiman, Russell, Venable and Louis (2008) showed no benefits of facilitation and peer interaction during a small-scale experimental study. Second, in a similar experimental study Russell et al. (2009) found no differences in OPD's impact when manipulating the amount of supportive interactions provided by content experts, online facilitators and peers.

The Present Study

Since we have strong evidence for OPD's effectiveness (e.g., O'Dwyer et al., 2010), the next logical step is to work to *improve* it. Indeed, the small, inconsistent student outcomes observed by O'Dwyer et al. imply that there is some room for improvement in OPD's effect on in this area. This study, then, examines the effectiveness of OPD for teachers vis-à-vis its design and implementation features. For this study, we first attempt to build on findings reviewed earlier with the following rationale: It could be assumed that research-based knowledge from the disparate face-to-face PD and (more general) online learning literatures can be extrapolated to OPD. However empirical evidence which links these design and implementation features directly to OPD effectiveness is preferable. In particular, we attempt to replicate findings regarding linking computer proficiency, school support, content focus, coherence, and an array of active learning variables to OPD effectiveness. Given that other literature on the effectiveness of OPD is scant, another contribution of this paper is the investigation of the effects of fourteen other variables not examined previously in the OPD literature (see Tables 1 and 2).

Our approach to studying OPD is in accordance with the principle that research on the effectiveness of an intervention should be coherent with the design of that intervention. In the case of teacher professional development (inclusive of OPD), the mechanism by which it theoretically operates to effect educational change is as follows: (a) teachers participate in PD (which varies along myriad design and implementation dimensions), (b) this participation changes their knowledge, skills, beliefs or attitudes, (c) their classroom practices then change accordingly, and finally (d) student outcomes improve (e.g., Desimone, 2009). Thus, the present study investigates relationships between OPD design and implementation features and each of three successive OPD outcomes: teachers' self-reported levels of knowledge, classroom practice, and their students' achievement—all aspects of various PD evaluation frameworks (e.g., Desimone, 2009; Guskey, 2000; Ketelhut, McCloskey, Dede, Breit, & Whitehouse, 2006).

Our approach affords not only the ability to discover which, if any, factors matter, but also *where* in this chain of events each factor has its effect. As an example, school culture might not affect what teachers learn during OPD, but might instead influence their later implementation of that knowledge in the classroom. Alternatively, particular student characteristics might not influence teacher learning during professional development but could moderate OPD's impact on student achievement. Examining variation in design and implementation features with respect to multiple outcomes should provide a nuanced understanding of the effectiveness of OPD.

In addition to examining the effects of various design or implementation features, we also seek empirical evidence for this chain of successive outcomes. This is done by modeling teacher knowledge after the course as a predictor of improvement in classroom practice, and both teacher knowledge after the course and improvement in classroom practice as predictors of improvement in student achievement. Notably, including these variables as mediators also allows us to examine the effects of various factors on OPD's "later" outcomes (e.g., improved classroom practice) *above and beyond*—or distinct from—the effects of its "earlier" outcomes (e.g., teacher knowledge gains). Aside from our substantive findings, another contribution of this paper is that it provides an example of the utility of this approach to modeling the effectiveness of OPD.

Our data source for the present study was the e-Learning for Educators (EfE) Initiative. The EfE initiative is a U.S. Department of Education-funded project implemented over the past five years in ten states. EfE is predicated on the belief that scheduling and access represent critical barriers to teachers' participation in "high-quality" professional development. The project delivers via the Internet, ongoing OPD courses that are fully online, facilitated, and asynchronous. Each EfE course, delivered through a course management system, is six to seven weeks long. A typical session involves a selection of online readings, an activity (e.g., viewing an online video or creating a product), and facilitated discussion in response to a session-related prompt. This initiative was the subject of O'Dwyer et al.'s (2010) four randomized controlled trials as well as an external evaluation conducted by Boston College's Center for the Study of Testing, Evaluation and Educational Policy.

Methods

This study involved secondary analysis of teacher self-reported data from the EfE evaluation. The large-scale, multi-state implementation of this initiative likely affords some variability requisite for the explanation of variance in the outcomes of its courses. The institutional review board at the authors' institution approved this study.

Participants

Participants were elementary and secondary teachers from nine[1] states who participated in an EfE course. For teachers represented multiple times in our dataset, we only include evaluation data from their first course. In addition, we only include teachers who voluntarily completed pre-, post-, and follow-up course evaluation surveys. After omitting cases with incomplete data, sample sizes were sufficiently large by conventions ($N/k = 20$): $N/k = 68.4$ for the model explaining teacher knowledge; $N/k = 76.8$ for the model explaining classroom practice; and $N/k = 56.0$ for the model explaining student achievement.

Instrumentation

The data were collected immediately prior to, immediately following, and between six months and one year after an EFE course. Nearly all of the data were collected via surveys administered online between June 2006 and July 2009. Most of the evaluation survey items have Likert response formats, although two (gender and state certification status) are dichotomous.

Some of the survey items were slightly modified for analysis. First, the response "I never needed it" to the item "Was technical assistance available throughout this workshop" (availability of technical assistance), was recoded as a central category between the alternative responses "Yes" and "No." Similar modifications were made to items measuring the effectiveness of online discussion and participant collaboration. Originally, response options for these two items were on a 5-point scale ["Not applicable" (0), "Very ineffective" (1), "Ineffective" (2), "Effective" (3) and "Very effective" (4)]. For analysis, "Not applicable" responses were re-coded as a central category (i.e. between "Ineffective" and "Effective"). These modifications reasonably assumed that participants responding "I never needed it" or "Not applicable" had a neutral opinion regarding these factors. Next, gender was dummy coded such that zero and one represented "Male" and "Female," respectively. Table 1 summarizes all intact (or slightly modified) evaluation items utilized for this study.

[1] Teachers from a tenth state did not participate in the evaluation.

Table 1

Summary of Single Evaluation Items Submitted to Analysis

Variable	Evaluation item	Response format
Improvement in classroom practice	The workshop enabled me to improve my classroom instruction	Agreement
Prior teacher knowledge	Based on the workshop description, how knowledgeable are you in the workshop content?	Not knowledgeable = 1; Somewhat knowledgeable = 2; Knowledgeable = 3; Very knowledgeable = 4
Gender	Do you identify as	Male = 0; Female = 1
State certification status	Do you hold a state certification for your current work title?	No = 0; Yes = 1
School support	My school supports the use of this workshop content in my classroom instruction	Agreement
Providing helpful feedback	How successful was the facilitator at [providing helpful feedback]?	Effectiveness
Keeping discussions on-topic	How successful was the facilitator at [keeping discussions on-topic]?	Effectiveness
Fostering stimulating discussion	How successful was the facilitator at [fostering stimulating discussion]?	Effectiveness
Encouraging active participation	How successful was the facilitator at [encouraging active participation]?	Effectiveness
Session reading effectiveness	Rate the effectiveness of [session readings] in helping you learn the workshop material.	Very ineffective = 0; Ineffective = 1; Not applicable = 2; Effective = 3; Very effective = 4
Online discussion effectiveness	Rate the effectiveness of [online discussion] in helping you learn the workshop material.	
Creating a usable project effectiveness	Rate the effectiveness of [creating a usable product by the end of the workshop] in helping you learn the workshop material.	
Participant collaboration effectiveness	Rate the effectiveness of [collaborating with other participants] in helping you learn the workshop material.	
Facilitator knowledgeableness[a]	The facilitator was knowledgeable in this content area	Agreement
Discussion topic relevance[a]	The topics chosen for discussion were relevant	Agreement
Discussion topic beneficence[a]	The topics chosen for discussion were beneficial	Agreement
Setting a welcoming tone[a]	How successful was the facilitator at [setting a welcoming tone for the workshop]?	Effectiveness
Clearly communicating expectations[a]	How successful was the facilitator at [clearly communicating expectations for activities]?	Effectiveness
Being accessible for support[a]	How successful was the facilitator at [being accessible for support]?	Effectiveness
Ease of content transferability[a]	The content of this workshop is easily transferable to the classroom.	Agreement
Organization[a]	The workshop was well-organized	Agreement
Interface user-friendliness[a]	The workshop website was user-friendly	Agreement
Culturally unbiased materials[a]	The workshop materials were culturally unbiased	Agreement
Availability of technical assistance[a]	Was technical assistance available throughout this workshop?	No = 0; I never needed it = 1; Yes = 2
Adequacy of compensation[a]	I received adequate credit or compensation for taking this workshop	Agreement
Linking pedagogical skills with content effectiveness[a]	The workshop effectively linked pedagogical skills and content	Agreement

Note. Agreement = 4-point scale: "Strongly disagree" (1), "Disagree" (2), "Agree" (3), and "Strongly agree" (4); Effectiveness = 4-point scale: "Very unsuccessful" (1), "Unsuccessful" (2), "Successful" (3), and "Very successful" (4).
[a]This variable was included in the final, exploratory regressor block.

In addition to employing single survey items, this study also constructed five multi-item composites: (a) teacher knowledge, (b) improved student achievement, (c) coherence, (d) clarity of goals and expectations, and (e) computer proficiency (see Table 2). Principal component and reliability analyses provided evidence of the unidimensionality and internal consistency of each composite variable (see Table 2). With the exception of the reliability of the two-item teacher knowledge composite (α = .52), these analyses provided evidence for the adequacy of the composites. All composites were the mean value of their constituent items.

Table 2

Summary of Composite Measures and Scale Analyses

Composite	Reliability analysis	Principal components analysis	
	α	Eigenvalue for first factor	Percent of explained variance
Teacher knowledge outcome	.52	1.35	67.50
Improved student achievement	.86	2.36	78.57
Coherence	.86	1.76	87.89
Clarity of goals and expectations	.93	1.86	93.01
Computer proficiency	.93	5.46	68.26

We constructed the teacher knowledge outcome from two parallel items administered on the post-course and follow-up surveys. We employ this composite learning outcome both to improve the stability of the measure and capture OPD's long-range impact. The two items were: "Having completed the workshop, how knowledgeable are you about the content presented in this workshop?" and "Now that some months have passed since taking the workshop, rate how knowledgeable you feel about the workshop content." The responses for the first item were: Not knowledgeable = 1; Somewhat knowledgeable = 2; Knowledgeable = 3; and Very knowledgeable = 4. The responses for the second item were: Not at all knowledgeable = 1; Not very knowledgeable = 2; Knowledgeable = 3; and Very knowledgeable = 4. Item factor loadings for the first principal component were .82 for both items.

The improvement in student achievement composite consisted of three items administered at follow-up: (a) "Students showed better academic performance in the targeted content using the workshop contents/approaches," (b) "Students performed more difficult (in-depth) work in classes using workshop contents/approaches," and (c) "Student products were of a higher quality in classes using the workshop contents/approaches." The responses for these items were: Strongly disagree = 1; Disagree = 2; Agree = 3; and Strongly agree = 4. Item factor loadings for the first principal component were .85, .90, and .91, respectively.

The coherence variable was a composite of two posttest items: "This workshop was aligned with my school's professional development needs or plans," and "This workshop addressed areas of curricular and/or pedagogical need in my school or district." The responses for these items were the same as those for the student achievement items. Item factor loadings for the first principal component were .94 for both items.

The clarity of goals and expectations variable was a composite of two posttest items: "The workshop goals were clearly stated," and "The expectations for workshop participation were clear." The responses for these items were the same as those for the student achievement and coherence items. Item factor loadings for the first principal component were .97 for both items.

The computer proficiency variable was a composite of eight pretest items. Participants were asked to respond to the question, "How proficient are you at performing each of the following" for (a) "Navigating websites," (b) "Performing an Internet or library search for educational resources," (c) "Downloading documents," (d) "Uploading documents," (e) "Reading a threaded discussion," (f) "Posting comments to a threaded discussion," (g)"Installing support programs (e.g., QuickTime, RealPlayer, Flash, Java, etc.)," and (h) "Troubleshooting computer programs." The responses for these items were: I don't know yet = 0; Not proficient = 1; Somewhat proficient = 2; Proficient = 3; and Highly proficient = 4. Item factor loadings for the first factor ranged from .76 to .88.

One variable—course content—was created by the evaluation team. This variable originally included: technology, pedagogy, special populations, assessment and standards, and four subject matter areas (English language arts, mathematics, social studies and science). From this categorical variable, we created a dummy variable representing subject matter focus, by setting the four subject matter areas equal to 1 and all others equal to 0.

Analytic Approach

We conducted separate blockwise ordinary least squares (OLS) regression analyses to explain variation in each of our criterion variables (increased knowledge, improved classroom practice, and improved student achievement). The OLS modeling is identical for all three outcomes. The only exception is that we include the teacher knowledge outcome as a predictor of improved classroom practice, and both the teacher knowledge and improvement in classroom practices "outcomes" as predictors of improved student achievement. We chose this modeling approach because these variables constitute mediators in our professional development theory of action (see Figure 1). Due to the number of significance tests, we selected a significance level of .01.

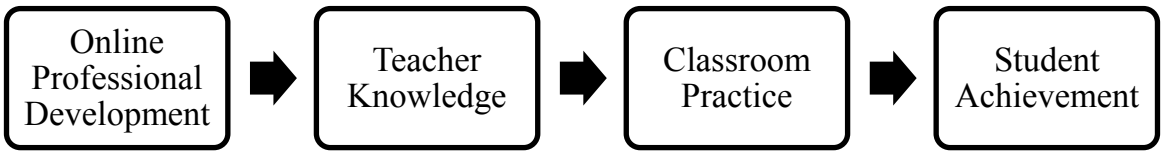

Figure 1. Conceptual model depicting the relationship between online professional development activities and its intermediate and ultimate outcomes.

For all three outcomes, the first block includes teacher and school contextual characteristics (standard entry). Specifically, the model includes prior knowledge, gender, state certification status, computer proficiency, and school support. The inclusion of prior knowledge in course content, gender, and state certification for one's current teaching position (a proxy for teacher training) is intended to partial out extraneous variance. The mediators (teacher knowledge and improvement in classroom practices) are also included in this first block for the classroom practice and student achievement regressions. The second regressor block includes two established characteristics of effective professional development, content focus and coherence (also standard entry). The third block contains OPD learner activity variables (analogous to active learning opportunities); this block allowed for the identification of OPD course "activities" that are related to its impact (again standard entry). The second and third blocks are intended to replicate what is known about traditional PD but apply them to an online context. The fourth block includes previously uninvestigated factors afforded by our data source (forward stepwise entry with $p < .01$ as the statistical criterion for entry).

Results

Table 3 presents descriptive statistics for all variables. Inspection of variance inflation factor values did not suggest major multicollinearity issues (VIFs < 5), though there is multicollinearity in these data. While the regression coefficients may be affected somewhat by this multicollinearity, we chose not to remove variables from the models. All reported coefficients are standardized and from the final model (see Table 4).

Our final regression model for teacher knowledge explained 32% of the variance (R_A^2) (see Table 4). The block of individual and school contextual variables explained 17% of the variance (ΔR^2). All variables within this block except for gender were statistically significant. As expected, participants who self-reported higher levels of knowledge in course content at the outset reported more knowledge after the OPD ($\beta = .13$). By including prior knowledge in the model, we have attempted to partial out variation in the outcome that is "due to" this predictor. We henceforth interpret the relationships between other predictors and the criterion in terms of *change* in knowledge. Increases in the computer proficiency composite ($\beta = .18$), and school support for instructional use of course content ($\beta = .16$) were both also associated with gains during the course. Not having a state certification for one's current teaching position ($\beta = -.08$) was also associated with significantly more gains.

The second and third blocks—those representing established predictors of PD effectiveness—respectively explained 5.7% and 6.3% additional variance in the teacher knowledge outcome. Within the second block, only coherence was statistically significant ($\beta = .09$). Increases in coherence were associated with gains in teacher knowledge. In the third block, only one of the eight learner activity variables was statistically significant: the effectiveness of session readings ($\beta = .08$). Increases in the rated effectiveness of this online course element were associated with teacher knowledge gains.

Table 3

Descriptive Statistics for All Variables

	Teacher knowledge (N = 1231)		Classroom practice (N = 1228)		Student achievement (N = 1008)	
Measure	M	SD	M	SD	M	SD
Teacher knowledge outcome	3.37	.45	3.37	.45	3.41	.44
Improvement in classroom practice	-	-	3.33	.60	3.41	.56
Improvement in student achievement	-	-	-	-	3.06	.49
Prior teacher knowledge	2.24	.71	2.24	.71	2.25	.71
Gender	.89	.32	.89	.32	.89	.31
State certification status	.94	.23	.94	.24	.95	.22
Computer proficiency	2.66	.88	2.67	.88	2.67	.86
School support	3.34	.59	3.34	.59	3.40	.57
Content focus	.52	.50	.52	.50	.53	.50
Coherence	3.58	.49	3.58	.49	3.61	.48
Providing helpful feedback	3.70	.52	3.70	.52	3.72	.50
Keeping discussions on-topic	3.68	.51	3.68	.51	3.70	.50
Fostering stimulating discussion	3.63	.55	3.63	.55	3.65	.54
Encouraging active participation	3.71	.48	3.71	.48	3.73	.47
Session reading effectiveness	3.43	.56	3.43	.56	3.45	.55
Online discussion effectiveness	3.44	.69	3.44	.69	3.46	.66
Creating a usable project effectiveness	3.49	.63	3.48	.63	3.51	.60
Participant collaboration effectiveness	3.31	.79	3.31	.79	3.33	.76
Facilitator knowledgeableness	3.74	.45	3.74	.45	3.75	.45
Discussion topic relevance	3.75	.45	3.75	.45	3.76	.44
Discussion topic beneficence	3.74	.47	3.74	.47	3.76	.46
Setting a welcoming tone	3.83	.40	3.83	.40	3.84	.38
Clearly communicating expectations	3.74	.48	3.74	.48	3.75	.47
Being accessible for support	3.75	.48	3.75	.48	3.76	.47
Ease of content transferability	3.66	.51	3.66	.51	3.69	.49
Clarity of goals and expectations	3.71	.48	3.70	.48	3.72	.47
Organization	3.74	.46	3.74	.46	3.75	.46
Interface user-friendliness	3.68	.51	3.68	.51	3.69	.51
Culturally unbiased materials	3.72	.47	3.72	.47	3.73	.46
Availability of technical assistance	1.48	.54	1.48	.54	1.49	.54
Adequacy of compensation	3.49	.59	3.49	.59	3.51	.58
Linking pedagogical skills with content	3.55	.52	3.55	.52	3.57	.52

The stepwise procedure entered one additional variable into the teacher knowledge model (explaining an additional 3.1% of the variance). In particular, the extent to which the course content was easily transferable to the classroom (β = .21) was associated with teacher knowledge gains. The absolute magnitudes of the final teacher knowledge model's standardized regression coefficients (βs) were generally small (.08-.21). In this final model, the variables most related to the criterion were the ease of content transferability (.21), computer proficiency (.18), and school support (.16).

Our final OLS regression model for improved classroom instruction explained 42% of the criterion variance (R_A^2) (see Table 4). The first block of individual and school contextual variables accounted for nearly all of this variance (41.6%). However, only two predictors in this block, the teacher knowledge mediator (β = .22) and school support for instructional use of course content (β = .51), were statistically significant. Increased self-reported knowledge after the OPD course was associated with improvement in self-reported classroom practice. School support for instructional use of course content was also associated with improvements in classroom instruction; the magnitude of this relationship (i.e., β = .51) is notable. None of the variables in the other three blocks were significant.

Our final OLS regression model for improved student achievement explained 20% of the criterion variance (R_A^2) (see Table 4). The individual and school contextual variables explained 16.6% of the variance. However, only the improved classroom practice mediator was statistically significant (β = .31), indicating improved classroom practice was related to improved teacher-reported student achievement. None of the variables in the second and third blocks were statistically significant at .01. The stepwise procedure added one variable to the model, the availability of technical assistance, which explained a very small additional amount of variance (.7%). Increases in the availability of technical assistance were associated with increases in student achievement (β = .09).

Table 4

Summary of Blockwise Linear Multiple Regression Analysis

Predictors	Teacher knowledge	Classroom practice	Student achievement
Block 1			
Prior knowledge	.13***	-.03	-.02
Gender	-.00	.03	.03
State certification	-.08**	.03	.01
Computer proficiency	.18***	.01	.05
School support	.16***	.52***	.01
Teacher knowledge	-	.22***	.06
Classroom practice	-	-	.31***
Block 2			
Content focus	-.01	.01	-.06
Coherence	.09**	.02	.07
Block 3			
Providing helpful feedback	.05	-.02	.00
Keeping discussions on-topic	.05	.01	-.12
Fostering stimulating discussions	-.06	.02	.14
Encouraging active participation	.01	.04	.00
Session readings	.08**	.02	.03
Online discussions	.06	.03	.01
Creating a usable project	.06	.02	.08
Participant collaboration	.06	-.00	.02
Block 4			
Ease of content transferability	.21***	-	-
Availability of technical assistance	-	-	.09**
Model *F*	36.35***	56.26***	14.51***
R^2	.32	.43	.21
R^2_A	.32	.42	.20

Note. All reported regression coefficients are standardized. **$p < .01$. ***$p < .001$.

Discussion

With this study, we have attempted to explain variation in OPD's intermediate and ultimate outcomes. We find clear evidence for the validity of the teacher-practice-student achievement PD conceptual framework (see Figure 1). Consistent with earlier studies by Garet, Porter, Desimone, Birman and Yoon (2001) and Ingvarson, Meiers and Beavis (2005), teacher knowledge predicts improvements in classroom practice, which in turn predicts improvements in student outcomes. It would seem that this series of events must be in place in order to advance student achievement outcomes with OPD or PD.

For teacher knowledge, the statistical significance of prior knowledge and state certification status underscores the importance of accounting for background knowledge and partialing out extraneous variance in an investigation such as this. Regarding the state certification finding, Garet et al. (2001) did find a similar inverse relationship between having an in-field certification and changes in their outcome, teaching practices. This might suggest that the out-of-field teachers stand to gain more from OPD (or any PD for that matter) than their certified counterparts. However, supplemental analyses showed that in- and out-of-field teachers did not differ significantly in terms of their pre-course knowledge.

More importantly, we replicate findings that participants' computer proficiency [discussed by Zhao et al. (2005) and Tallent-Runnels et al. (2006)], school support (Ingvarson et al., 2005), and coherence (Garet et al., 2001) are related to teacher knowledge gains. The first finding clearly suggests that developers of OPD should be mindful of participants' computer proficiency. Our interpretations of the school support and coherence findings center on teachers' motivations. It is possible that teachers' perceptions of school support for implementing PD content may bear on their motivation to learn that content. Teachers may similarly be more motivated to learn PD that is coherent, or aligned, with local professional development initiatives and needs.

Next, our learner activity block showed that the rated effectiveness of session readings was related positively to the amount of knowledge growth reported during the course. To the best of our knowledge, this is the first study evidencing a mechanism by which OPD may be producing effects and also that the quality of this mechanism does indeed matter. Not surprisingly, online course *quality* matters (see Tallent-Runnels et al., 2006).

In addition, we find evidence that more teacher learning takes place when OPD content can be transferred easily to a classroom setting. We suspect that this finding indicates that teachers learn more (or are perhaps motivated to learn more) in OPD that has practical, concrete, and readily usable, rather than theoretical, content (Darling-Hammond & McLaughlin, 1995; Guskey, 2002). In an earlier OPD study, Reeves and Pedulla (2011) found that teachers were more *satisfied* with such easily transferable content. Moreover, this finding is consistent with the adult learning literature, which suggests that this population desires knowledge that can be applied immediately (Cercone, 2008).

On the other hand, we do not find that a focus on content (i.e. math, language arts, etc.) is associated with increases in teacher knowledge. We offer the following explanation for the incongruence of this finding and the PD effectiveness literature: It is worth keeping in mind that typical investigations of PD effectiveness focus on PD that is implemented by schools or districts; it is for this form of PD that a focus on content has been shown to be most effective. In an OPD context, where teachers voluntarily enroll, it is possible that teachers may be motivated to learn the course material, whatever its content might be.

For improvements in classroom practice, two statistically significant variables accounted for 42% of the variance. First, we find a statistically significant effect of the teacher knowledge mediator. Second, school support for instructional use of workshop content was also significantly related to improvements in classroom practice. The fact that this variable is statistically significant for this particular outcome is understandable, as it captures the context in which teachers actually engage in their classroom practice. School support is, as Ingvarson et al. (2005) suggested, an "an important *enabling* condition" (p. 15) for curricular implementation of content and pedagogical change. In addition, while school support was also significant for the teacher knowledge analysis, the magnitude of the effect is larger for classroom practice, suggesting that school support is particularly important for classroom implementation. This finding, more than any other in this study, exemplifies the utility of linking particular design/implementation features to particular outcomes when studying the effectiveness of OPD. For classroom practice, we also do not find evidence for an effect of content focus, a result for which we offered an explanation earlier. We also do not find an effect of coherence on classroom practice, although this factor was statistically related to changes in teacher knowledge.

Our only finding for the student achievement analysis was that the availability of technical support was associated with improved student outcomes. This finding converges with a finding by Penuel, Fishman, Yamaguchi and Gallagher, (2007) that the provision of technical support to teachers was predictive of PD content implementation. A need for technical support is not surprising given evidence for non-stellar computer proficiencies among some teachers (Reeves & Li, 2012).

This study's findings must be interpreted in light of its limitations, which include possible selection biases, and more crucially its data and design. Limitations such as these are quite characteristic of observational studies, including much of the published literature cited throughout this article. Given these potential threats, however, a number of things are worth noting. In light of the possible selection bias, we restricted our target population to only teachers who chose to enroll in an OPD course. With regard to internal validity, our study did attempt to exercise control of extraneous variables that might confound observed relationships. Because of our study's correlational design, we present here only functional rather than bona fide causal relations. Next, despite some measurement limitations, each of the outcome variables were measured, in part, at least six months after the course, which is a strength of the measurement. The fact that data were self-reported is also a limitation. Since research along these lines was

needed, we believe that the evidence reported here represents an important first step toward understanding some of the variables that can maximize the impact of OPD.

Nevertheless, future research should surely attempt to replicate findings reported here using samples of teachers in different OPD contexts and instrumentation designed specifically to measure the variables of interest. More broadly, further research is needed on how to measure effectiveness in and evaluate OPD (Dede et al., 2009). Research utilizing data collected within and by course management systems should also prove informative.

Barring these limitations and the need for additional research, this study responds to calls in the literature for research on the effectiveness of online professional development (e.g., Ginsberg et al., 2004). Taken altogether, these findings suggest a number of factors that are related to OPD's intermediate and ultimate impacts. Given earlier research, coupled with the findings presented here, we offer the following implications: Clearly, designers and implementers, as well as facilitators, of OPD should be mindful of teachers' computer proficiency. As a potential solution to this issue, a built-in or stand-alone training module for the relevant skill set could be made available to participants. Next, school support for the use of knowledge garnered through OPD appears important, having shown up as a predictor of both teacher knowledge and improved classroom practice. This finding implies that it might behoove administrators to endorse openly the curricular implementation of OPD or PD content. Regarding the in-service training itself, OPD that is coherent with professional development needs and initiatives in teachers' schools and features high-quality readings can be expected to yield a greater impact. This study also suggests a benefit to teacher learning when the content is practical, concrete and readily usable, and relevant to teachers' day-to-day professional needs. Finally, making available technical support during OPD may prove beneficial.

In conclusion, given that dissemination was an explicit part of Boston College's role in the e-Learning for Educators initiative, this study shares *empirical* lessons learned for others hoping to design and implement facilitated OPD for teachers. The study reported here represents a much-needed move toward effective professional development theory and model building (Dede et al., 2009; Desimone, 2009). It is clear that high-quality professional development, including that offered online, can help in tackling school reform and meeting the ambitious standards for student achievement called for in the No Child Left Behind Act 2001 (20 U.S.C. § 6319 (2008), Borko, 2004) and that will no doubt continue with its reauthorization in the coming year.

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