

Comparing Self-paced and Cohort-based Online Courses for Teachers

Michael Russell

Boston College

Glenn Kleiman

North Carolina State University

Rebecca Carey

Education Development Center

Joanne Douglas

Boston College

Abstract

The study investigated whether online professional development courses with different levels of support have different impacts on teacher outcomes. Variations of an online course for middle school algebra teachers were created for four experimental conditions. One was a highly supported condition, with a math education instructor, an online facilitator, and asynchronous peer interactions among participants available as participants worked through the course together. Another was a self-paced condition, in which none of the supports were available. The other two conditions provided intermediate levels of support. All conditions showed significant impact on teachers' mathematical understanding, pedagogical beliefs, and instructional practices. Surprisingly, the positive outcomes were comparable across all four conditions. Further research is needed to determine whether this finding is limited to self-selected teachers, the specifics of this online course, or other factors that limit generalizability. (Keywords: Online professional development, distance learning, e-learning, online facilitation, self-paced learning)

INTRODUCTION

Increasing demand for teacher professional development and significant advances in information and communication technologies have led to a proliferation of online professional development programs (OPD) in recent years (Dede, 2006; Galley, 2002). Online courses and workshops have become common in both preservice and inservice teacher education programs, using a variety of technologies to provide learning opportunities for educators that differ from traditional, face-to-face courses and workshops in many ways. First and foremost, online learning can be used to bridge distance and time: Educators can participate via the Internet or other technologies rather than travel to a specific site, and interactions can be asynchronous so that participants do not need to be available at the same time. Online learning can thereby broaden the professional learning opportunities available to educators. In addition to its logistical advantages, OPD can provide expertise and resources to locations

where they would not be available otherwise; provide new means to interact with experts and colleagues; enable educators to experience for themselves new forms of teaching and learning; and make participation in coaching, mentoring, and professional learning communities more accessible (Kleiman, 2004).

Online professional learning can be provided in many forms. For example, distance learning classrooms enable individuals to participate in a class via video conferencing, with the goal of making the online experience as close as possible to an in-class experience. As this approach requires simultaneous participation, it bridges distance but not time. Alternatively, an online course can be conducted completely through asynchronous interactions, so that each participant can work with the course resources and add their own responses and questions to the course discussion at any time. Technologies can range from multipoint video conferencing to one-way transmission of Web-based resources, but they often involve synchronous and/or asynchronous voice and text exchanges among participants and instructors. Another variation is self-paced online courses, in which each participant works through a series of resources and activities at his or her own pace, often with an instructor available to respond to questions and provide feedback about submitted assignments.

To be effective, OPD for teachers must reflect the principles of effective professional development. Research has led to agreement on a number of key principles of successful professional development practices for K–12 educators. Major studies and syntheses by Stigler and Stevenson (1991), Darling-Hammond and McLaughlin (1995), Sparks and Hirsch (1997), Ball and Cohen (1999), National Foundation for the Improvement of Education (1996), Borasi and Fonzi (2002), and others consistently agree that professional development is more effective when it:

- Fosters a deepening of subject-matter knowledge, a greater understanding of learning, and a greater appreciation of students' needs
- Centers around the critical activities of teaching and learning—planning lessons, evaluating student work, developing curriculum, improving classroom practices, and increasing student learning—rather than on abstractions and generalities
- Builds on investigations of practice through cases that involve specific problems of practice questions, analysis, reflection, and substantial professional discourse
- Values and cultivates a culture of collegiality, involving knowledge and experience sharing among educators; and,
- Is sustained, intensive, and continuously woven into the everyday fabric of the teaching profession through modeling, coaching, and collaborations.

Although there is general consensus about the key principles of effective teacher professional development, in actual practice, factors such as required expertise, funding, access from rural areas, or opportunities for collaboration may inhibit implementation. OPD can incorporate characteristics associated with effective face-to-face professional development and offers a number of advantages over face-to-face formats. Because Internet access has become nearly universal in

K–12 schools and widespread in teachers' homes, OPD provides teachers with opportunities to engage in forms of training that may not be available within their local areas. Teachers can participate in professional development during times that are convenient, receive job-embedded support that addresses immediate classroom needs, customize programs to better suit their own individual learning styles, interact with material through a variety of visual or other multimedia formats, and gain valuable computer and online technology skills (Docherty & Sandhu, 2006; Garrison & Cleveland-Innes, 2005; Ginsburg, Gray, & Levin, 2004; National Staff Development Council, 2001; Richardson, 2002; Spicer, 2002; Treacy, Kleiman, & Peterson, 2002).

Due to its accessible and flexible modes of communication, OPD can also support the growth and maintenance of teacher learning communities. The Internet can connect teachers to broad networks of professionals, provide them with access to a wide array of learning experiences, and help to reduce the isolation that has often accompanied traditional forms of classroom teaching (DuFour, 2002; Ginsburg, Gray, & Levin, 2004; National Staff Development Council, 2001). Some researchers and educators argue that OPD can promote deeper levels of communication and thought among teachers than face-to-face forms of professional development. Because online programs can store written records of teacher conversations, and because teachers can participate in group discussion asynchronously, OPD allows teachers to contribute ideas when they are ready and to be more reflective in their written online comments (Spicer, 2002; Treacy, Kleiman, & Peterson, 2002).

Although researchers have reached a broad consensus about the general components of high-quality K–12 teacher professional development in face-to-face contexts (Sparks, 2002), many questions remain about the design and delivery of effective OPD. Recent studies have focused on describing the characteristics of existing OPD programs, but little research has examined specific OPD formats and their impacts on teacher practice and student learning (Ginsburg, Gray, & Levin, 2004; Lawless & Pellegrino, 2007; Whitehouse, Breit, McCloskey, Ketelhut, & Dede, 2006). In a strategic analysis of OPD for mathematics teachers, Ginsburg, Gray, and Levin (2004) reviewed the quality and effectiveness of more than 40 OPD programs, judging them against what is known about similar evidence for effectiveness and quality in traditional face-to-face professional development. Overall, Ginsburg et al. found that the OPD sites lacked rigorous independent assessments of the impact of OPD on teacher or student outcomes. Similarly, in a review of the literature on technology professional development for teachers, Lawless and Pellegrino (2007) indicate that the success of professional development is typically judged based on anecdotal evidence or the results of surveys in which teachers indicate their satisfaction with the experience or their perception of its usefulness to their work. Consequently, we know only what teachers think about their professional development activities, not what they actually learn, how it changes their pedagogies, or how it impacts student learning (Lawless & Pellegrino, 2007).

Key Components of Online Professional Development

The role of facilitators and content experts in online courses has been the topic of many OPD design recommendations and some research. Researchers and practitioners such as Anderson Rourke, Garrison, and Archer (2001), Treacy et al. (2002), and Yang and Liu (2004) suggest a number of functions that facilitators should serve to enhance the quality of OPD programs. For example, they should investigate participants' needs, require regular contributions to online discussions, and provide clear structure for participant dialogue to promote active inquiry and thoughtful online discourse. They argue that facilitators need to pose engaging questions, challenge participants' positions, identify areas of conflict, and help participants make connections between different ideas. Some researchers have found that OPD facilitators cannot simply ask teachers to describe how they teach and to "be specific" in their online postings when examining issues surrounding classroom instruction; more meaningful discourse arises only when facilitators request participants to analyze, compare, and reflect upon concrete cases (Nemirovsky & Galvis, 2004). Online facilitators also play an important role in eliciting the contributions of less active participants, managing participants who may dominate discussions, and creating a comfortable and social environment (Anderson, et al., 2001; Florida Instructional Technology Resource Center at UCF, 2000; Sargeant, Curran, Allen, Jarvis-Selinger, & Ho, 2006; Treacy, Kleiman, & Peterson, 2002).

In certain subject areas, OPD may be most effective when a content expert acts as a facilitator (Anderson, et al., 2001). Content experts can help diagnose and correct teacher misconceptions, recommend useful and reliable resources, validate new insights, and provide context for new learning. Furthermore, the presence of a knowledgeable online instructor can help participants synthesize course material and progress beyond the initial stages of idea discovery and exploration (Garrison & Cleveland-Innes, 2005).

Although the recommendations that researchers and practitioners have issued may be helpful to those currently designing and implementing OPD programs, as previously noted, most existing recommendations lack a base in solid experimental research. Consequently, the true impacts of OPD content expert instructors, facilitators, and participant interaction remain unclear. To help build knowledge about the effectiveness of different OPD models on teacher learning, the study presented in this article conducted a large-scale experiment to examine the following question: Do online professional development models with different types of facilitation, levels of interaction among participants, and pacing schedules have different impacts on teacher outcomes?

The research addresses whether online courses for educators should be designed to optimize schedule flexibility for participants, to optimize interactions between each individual participant and the instructors, or to optimize interactions among a cohort of peers participating in the course together. The decision about what to optimize is fundamental to both designing and implementing online professional learning programs. Drawing upon prior research observations and recommendations, we hypothesized that OPD courses will have greater impact on teachers' knowledge and practice when interactions with content experts, online facilitators, and peers are available.

The research reported in this article was one of a series of studies conducted to provide a research basis to inform these types of decisions. A prior study by the same research team (Carey, Kleiman, Russell, & Douglas, 2008) compared the learning outcomes from two designs of online workshops for teachers of middle school mathematics. One was a self-paced course that participants completed on their own schedules without interacting with peers and with minimal interaction with instructors. Participants in this condition could complete the 10-session workshop on their own schedules, with the only time constraint being the completion of all the required assignments in a maximum of 10 weeks. The second type of design was a cohort-based course in which participants worked through the material following a structured timeline and frequent interactions with both instructors and peer participants were integral to the design of each session. The interactions were asynchronous and text-based, so that each participant could complete the session assignments and contribute to the discussion whenever it was convenient during the 1-week window for each session. The course goals and content were kept as constant as possible across the two designs. Although we hypothesized that the cohort-based course would have a larger effect on the intended learning outcomes, the study found that both versions of the course were equally effective at creating the desired changes in teachers' pedagogical beliefs, knowledge of teaching mathematics, and instructional practices.

The study presented here sought to replicate and extend this prior unexpected finding by comparing the effects of four variations of an online course, again for middle school mathematics teachers. We designed these variations to enable us to investigate the value of various types of interactions within an online course for adult professional learners, ranging from a highly interactive cohort model facilitated by content and online interaction experts to a fully self-paced course with minimal interactions.

In the sections that follow, we describe the course and levels of interactivity that were varied across the four conditions in the study. We then describe the methodology employed to recruit and assign teachers to groups, as well as the data-collection instruments employed for this study. Finally, we present the findings from the study and explore the implications these findings may have for the design and delivery of online professional development.

Online Course: Building Algebraic Thinking in the Middle Grades

The online course employed for this study was titled Building Algebraic Thinking in the Middle Grades and was based on a book authored by Mark Driscoll titled *Fostering Algebraic Thinking* (Driscoll, 1999). The course was developed by mathematics experts at Education Development Center Inc. (EDC) and focused on the algebraic concepts of patterns and functions. We provided four versions of the course to test the impact of different types of interactions. As far as possible, the goals, content, and activities were the same across all four versions.

The primary learning goals of the course were to increase teachers' abilities to (a) understand the mathematics of patterns and functions, (b) recognize and

Table 1: Course Sessions and Summary

Session Number and Title	Content Summary
Session 1: Orientation & What Is Algebraic Thinking?	Participants completed the precourse surveys, an orientation to the course, and an orientation to the technology needed for the assignments. Participants were introduced to various definitions of algebraic thinking, including the definition primarily used in this course, and were asked to compare those definitions with their current understanding.
Session 2: Exploring Algebraic Thinking in Patterns—Examining Your Own Thinking	Participants focused on their own mathematical thinking when doing pattern problems. These activities served as a starting point when participants examine student thinking in later sessions.
Session 3: Analyzing Students' Algebraic Thinking about Patterns	Participant focus turned to examining students' algebraic thinking to better understand the nature of their misconceptions and difficulties.
Session 4: Using Teacher Questioning to Develop Algebraic Thinking	To conclude the patterns section of this course, participants turned to developing good questioning techniques that can help students develop algebraic thinking in the context of patterns activities.
Session 5: Conducting Your Student Interview	This session asked participants to explore how to foster students' algebraic thinking habits as they build generalization skills essential to understanding functions. Participants conducted two student interviews to gain insight into their algebraic thinking related to functions.
Session 6: Creating Meaning with Representations—Graphs without Numbers	This session explores ways participants could foster students' algebraic thinking habits as they learn to analyze and interpret graphs of functions.
Session 7: Creating Meaning with Representations—Tables, Graphs, Words, and Equations	This session continues the work with algebraic thinking related to functions and addresses ways to help students make sense of the relationship between different function representations.
Session 8: A Final Look at Algebraic Thinking	Participants complete and submit their final project and complete the postcourse surveys.

build on opportunities with their students for algebraic thinking in a variety of kinds of mathematics problems, (c) analyze students' mathematical thinking and identify misconceptions commonly found in students' work with patterns and functions, and (d) use specific instructional methods, especially questioning strategies, that encourage the development of students' mathematical thinking and their abilities to communicate mathematical ideas.

We divided the course activities into eight sessions, preceded by a brief orientation pre-session to familiarize participants with the technology and course expectations. Sessions contained readings, videos, mathematical activities for the teacher participants, and pedagogical activities such as preparing a lesson

Table 2: Supports Available in Each of the Four Conditions

Group	Mathematics Instructor	Online Facilitator	Peer interactions
1. Highly Supported	x	x	x
2. Facilitated Peer Support		x	x
3. Instructor Support Only	x	x	
4. No Support			

or interviewing students about their mathematics thinking. Depending upon the version of the course, session requirements also included participation in an asynchronous online discussion or completion of an individual journal entry. Participants were expected to spend about 4 hours per session and to complete a final project. The course content is summarized in Table 1, and the full course is available at http://www.curriki.org/xwiki/bin/view/Coll_edc1/BuildingAlgebraicThinkingThroughPatternFunctionandNumber-ProfessionalDevelopmentCourseforMiddleGradeMathTeachers.

EXPERIMENTAL CONDITIONS

The four versions of the delivered course varied in the types of supportive interactions available to participants. The course versions contained different configurations of the following three types of supports:

1. A mathematics education content expert who provided detailed feedback on assignments, responded to questions about mathematics content and/or pedagogy, and, in courses that also provided an asynchronous discussion option, contributed both questions to participants and responses to participants' messages in the discussions
2. An online facilitation expert who was trained to encourage and guide participation in online interactions. The online facilitation expert welcomed participants to the course, sent twice-weekly reminders to participants about assignment and activities, tracked participation, engaged participants in online discussions, and provided technical assistance when the need arose.
3. Interactions among the peer group of teachers participating in the course via an asynchronous, text-based discussion board. Participants could view and respond to each other's responses to discussion prompts contained in each session, share ideas, ask each other questions, and respond to questions from their peers.

These three types of supports are referred to in the remainder of this paper as (a) *mathematics instructor*, (b) *online facilitator*, and (c) *peer interactions*. In the four conditions of this study, the availability of each type of support is shown in Table 2. Each course condition is described in more detail below.

Each session of each version of the course contained preplanned questions. In courses with peer interactions, these questions were used to start online discussions, and the instructor, facilitator, and participants might then post additional

related questions according to the flow of the discussion. In the courses without peer interactions, each individual participant responded to the preplanned questions on their own, with no opportunities for follow-up questions.

Group 1 received a highly supported course that had both a mathematics instructor and online facilitator, both of whom were active in interacting with course participants, along with peer interactions. Participants were expected to progress through the 8-week sessions together and to engage in weekly interactions with other participants, the instructor, and the facilitator through an online, asynchronous, text-based discussion board. The instructors posed questions each week. Participants responded to the queries, to their colleagues' postings, and to additional questions the instructors posed as they attempted to guide the conversation toward deeper understanding of that week's topic. The online facilitators encouraged participants to use the discussion board as their primary means of communication with other participants and with the mathematics instructors, with a minimum expectation of one initial message and two responses to other messages. Participants, instructors, and facilitators also communicated with each other via e-mail occasionally to submit the three homework assignments, send feedback on the assignments, seek and provide technical support, and provide encouragement. On rare occasions, facilitators and individual participants communicated via telephone. The majority of phone interactions took place at the onset of the course, while participants were registering and completing the orientation tasks before the course began.

Group 2 provided participants with facilitated peer support, which involved an online facilitator and peer interactions without the mathematics instructor. In the absence of an instructor with mathematics education content expertise, the facilitator responded to participants' content questions by directing them to the participant discussion board and to other resources. In this condition, the facilitator also tracked participation and provided technical assistance. Participants were expected to progress through the eight course sessions together and to participate in weekly discussions with their peers. Each week, the facilitator posted a new question on the discussion board and then interacted as needed. She responded to lapses in discussion and to direct questions but, again, did not offer direct content instruction. Participants responded to the initial question, to each other's postings, and to additional queries the facilitator may have posed. Although the initial discussion questions for each session were preplanned and consistent across the conditions, follow-up questions varied according to the flow of the discussion.

Although the majority of the interactions occurred via the asynchronous discussion board, participants submitted homework assignments via e-mail, and the facilitator provided acknowledgement via e-mail to each participant that the assignment had been completed. On rare occasions, facilitators and individual participants communicated by phone. Again, the majority of phone interactions took place at the onset of the course while participants were registering and completing the orientation tasks.

Group 3 provided participants with instructor support only. In this condition, participants had access to both a mathematics instructor and an online

facilitator but did not have a means to interact with the other participants. As in Group 1, the instructor with expertise in the teaching of algebra provided feedback on the content of participants' weekly assignments. This instructor also provided direct answers to questions participants had about the content of assigned readings and activities. The online facilitator played a minor role and was responsible for helping participants stay on pace with the course material and addressed technical or administrative questions raised by individual participants. All communications between the participants and the instructors occurred via e-mail and were not shared with other participants. Finally, although participants were encouraged to complete weekly assignments, they were allowed to work through the course material at their own pace.

Group 4 received no support. Participants had access to only an online coordinator who did not take the role of an instructor and was available only to answer technical questions and to provide a cursory review of assignments submitted by participants. There was no access to a discussion board or interactions among participants. When participants asked questions about content, the coordinator would direct them to sections of the assigned reading. Participants were allowed to work through the course at their own pace. When they submitted an assignment, the only feedback they received confirmed that the assignment was received and that it fulfilled the requirement for the course. No other e-mails were initiated by the coordinator except for two messages that reminded participants of the passage of time and, in a few cases, requested that participants complete the data-collection instruments.

Participants who completed the course and the data-collection instruments were awarded either five quarter or three semester hours of graduate course credit or a stipend award of \$200.

Participants and Instructors

Participation in the study was limited to middle school teachers who were currently teaching at least one algebra course. Messages inviting teachers to participate in the study were distributed via a variety of listservs. Study participants included 231 teachers who responded to the invitation, were currently teaching pre-algebra or algebra to seventh or eighth grade students, and had a working e-mail address. Teachers were stratified by gender and randomly assigned to one of the four treatment groups, with initial registration in the four conditions ranging from 57 to 59 teachers. We then divided each group into two cohorts, A and B, to have fewer teacher participants per section of the course. The starting cohort groups for each condition ranged from 28 to 30 participants. Three instructors and four facilitators were hired to run the sessions. Instructors were required to be experienced middle school mathematics teachers who also had expertise in providing professional development in mathematics. The facilitators were not required to have a background in mathematics but were required to have experience in online facilitation. To control for the effect that an instructor may have on the learning outcomes of the course, each instructor and facilitator ran two different versions of the course.

Table 3: Instrument List

Instrument	Administered
Background survey	Precourse
Pedagogy survey	Pre- and postcourse
Math assessment	Pre- and postcourse
Student survey	Pre- and postcourse
Teacher log	Pre- and postcourse
Course evaluation	Postcourse

Data-collection Instruments

The study presented here focused on the effect that the four versions of the online course had on the intended outcomes of the course. To collect data about the intended outcomes, six instruments were employed. These instruments included a background survey, a pedagogical beliefs and practices survey, a measure of teachers' understanding of teaching algebraic concepts (referred to as math assessment), a student survey, a teacher log, and a course evaluation. As shown in Table 3, the background survey, pedagogy survey, teacher log, and the math assessment were administered prior to the start of the course. The pedagogy survey, math assessment, student survey, teacher logs, and course evaluation were administered after the course was completed. We describe each of the instruments briefly below; the complete instruments are available at <http://www.bc.edu/research/intasc/researchprojects/optimizingOPD/OPD.shtml>.

Background survey. The background survey was designed to collect demographic information and information about teachers' prior experiences with professional development and technology use. The majority of the items on the background survey were closed-response. In a few instances, participants were requested to type in numeric values that best represented their background.

The pedagogy survey. The pedagogy survey collected information about teachers' pedagogical beliefs and instructional practices. All items were closed-ended and asked teachers to either report the frequency with which they employed specific instructional techniques or to indicate the degree to which they agreed or disagreed with a statement that focused on the value of a given instructional practice. We took the vast majority of items we employed for this survey from two previous studies that focused on the relationships between pedagogical beliefs and practices and the use of instructional technology in the classroom (Becker, 1999; Russell, O'Dwyer, Bebell, & Miranda, 2004). The specific scales that we formed and the associated reliabilities included (a) Teacher-Centered Beliefs (.76), (b) Student-Centered Beliefs (.61), (c) Instructional Use of Technology (.55), (d) Having Students Do the Learning (.80), (e) Collecting and Reflecting on Student Work (.70), (f) Confidence in Teaching Math (.847), and (g) Confidence with Knowledge and Skills (.81).

Math assessment. The math assessment was designed to collect information about teachers' understanding of teaching the mathematical concepts covered

in the professional development course. The assessment required teachers to apply their understanding of a concept as they analyzed samples of student work and answered questions about what the student appeared to understand, what the student appeared to struggle with, and the actions the teacher would take to help advance the student's understanding. We administered the assessment twice—once in the first week and once in the final week. The assessment presented teachers with a sample of student work for a given problem related to patterns or functions. It then asked the teacher to respond to a series of questions about the student work. For each sample, teachers were asked to (a) identify the content and process goals measured by the task presented to the student, (b) assess whether the student appears to understand the mathematics required for the problem, (c) determine whether any misconceptions were present in the student work, (d) specify what they would like to know about the student's understanding based on the work sample, and (e) describe what questions or problems they would use to gain further insight into the student's understanding. Using a scoring guide that was shown to yield reliable scores (exact agreement exceeded 85% for all items), two trained readers with experience in teaching mathematics independently scored teacher responses. When discrepancies occurred, the readers discussed their scores before reaching a consensus score. The scoring guide employed the following 4-point scale:

1. does not meet expectations
2. partially meets expectations
3. meets expectations
4. exceeds expectations

Teacher logs. We designed the teacher logs to capture information about teachers' day-to-day pedagogical practices. We administered the teacher logs twice—once in the first week of the course and once in final week of the course. During each administration, teachers completed three logs, each of which consisted of a series of instructional strategies similar to those explored in the course. For each strategy, teachers were asked to indicate whether the strategy was (a) not used at all, (b) a minor component of the lesson, (c) a major component of the lesson, or (d) the most important component of the lesson. We then averaged the ratings provided for each activity across the logs recorded for each week.

Student survey. To help triangulate data provided by teachers via the pedagogy survey and the teacher logs, we asked teachers to administer a survey to students in their algebra classrooms. A total of 2,682 student surveys were received from algebra classrooms for 145 teachers for the precourse administration, and 2,125 student surveys were received from algebra classrooms for 125 teachers for the postcourse administration. The survey items asked students to indicate the frequency with which they engaged in specific learning activities (e.g., performing worksheets individually, working with partners to solve problems, sharing solutions with their class, etc.) and how often their teacher employed specific instructional strategies (e.g., asking students to explain how they solved a problem, showing students how to solve a problem, asking students to

respond to each others work, etc.). All items were forced-choice and were used to form scales that represent the degree to which students reported that they engaged in student-centered activities and in teacher-directed activities. A 4-point scale was employed for these items:

1. almost always
2. most of the time
3. once in a while
4. never

Hence, a low score for a given item indicated more frequent use of the given instructional strategy.

Course evaluation. We designed the course evaluation to collect information from teachers about the positive and negative aspects of the course. We administered the course evaluation only as a postmeasure.

FINDINGS

The primary research question examined in this study asked whether the four conditions that differed in the types and amounts of support provided to course participants affected teachers' mathematical understanding, their pedagogical beliefs, and their instructional practices. To this end, the majority of analyses we conducted for this study focused on comparing the effect of the four versions of the course on these three outcomes. To provide a better understanding of characteristics of the study participants, we first report descriptive statistics for several items on the background survey.

Characteristics of Study Participants

The majority of the participants were female (70%). Forty-eight percent indicated that they were younger than 40 years old. Twenty-nine percent of teachers indicated that they had been teaching for fewer than 5 years, 26% had taught for 5–10 years, 12% taught 10–15 years, and 29% taught for more than 15 years. Twenty-four percent of the participants had a college major in mathematics, 13% minored in mathematics, and 59% did not have undergraduate focus in mathematics. Sixty percent of participants had obtained a master's degree. Finally, 34% of participants had taken an online course previously. Although there were subtle differences among the groups on each of these demographic variables, none of the differences was statistically significant.

Completion Rate

Of the 231 participants who agreed to participate in the study, 46% dropped out of the course prior to completing all assignments and the required data-collection instruments. Analysis of those who dropped out of the study indicates that a larger percentage of participants dropped out of the highly supported group (53%) than the facilitated peer support (41%), instructor support only (45%), or no support (44%) groups. These percentages of participants dropping out of the course, however, did not differ significantly among the four conditions.

Table 4: Number of Discussion Board Messages per Session and Other Discussion

Discussion	Highly supported A	Highly supported B	Facilitated peer support A	Facilitated peer support B
Introductions	75	105	122	82
Session 1	63	88	82	58
Session 2	65	90	89	85
Session 3	53	106	71	104
Session 4	76	83	82	100
Session 5	52	56	51	72
Session 6	50	55	59	76
Session 7	37	54	56	63
Session 8	42	41	46	72
Other	31	48	19	46
Total	544	726	677	758
Participants (n)	12	16	17	17

The characteristics of those who dropped out also did not differ among the four treatment groups. The vast majority of dropouts were between the ages of 35 and 50. In addition, teachers who reported that they minored or majored in mathematics, were certified to teach mathematics, or were frequent computer users were more likely to complete the course. Follow-up surveys with the dropouts indicated that a large percentage were unable to complete the course due to personal (divorce, moving, death in the family) or health issues within their families involving themselves, their children, or their parents. A smaller number of dropouts indicated that they found the time requirements of the course too demanding on top of the time required by their teaching and family obligations. A very small percentage indicated that persistent problems with technology made it too difficult for them to complete the course. Similar high dropout rates have been reported in other studies on online courses for educators, and Diaz (2002) discusses the reasons this might be the case, including participants experiencing technical problems, course content not matching perceived needs, and limited time due to other professional and family demands.

Use of Discussion Boards for Peer Interactions

In the two conditions that had a discussion board available for peer interactions, results show that the participants used them often. Table 4 displays the number of messages posted within each cohort for each session of the course. Throughout the course, the average number of messages per person for each cohort was: 38.9, 40.3, 37.6, and 44.6. An informal analysis showed that the large majority of the messages were directly relevant to the course content.

Table 5: Comparison of Pedagogical Beliefs and Teacher Confidence Scale Scores

	Pre score	Post score	Post-pre	<i>p</i> value
Confidence teaching mathematics	-0.21	0.31	0.52	<.01
Confidence in mathematics knowledge and skills	-0.29	0.57	0.86	<.01
Teacher-centered	0.19	-0.28	-0.47	<.01
Student-centered	-0.22	0.31	0.53	<.01
Having students “do” the learning	-0.25	0.27	0.52	<.01
Technology use	-0.03	0.05	0.08	0.37
Collection of student work	-0.04	-0.03	0.01	0.88

Quality of the Online Course

Overall, participants rated the course to be of high quality. All groups reported that the assigned readings were valuable, that interactions with facilitators were helpful, and that they learned more from the course than they did from university and college courses they had taken previously. For nearly all items on the survey that asked about specific aspects of the course, mean ratings fell between *valuable* and *very valuable*.

To examine whether participants in each of the four versions had similar views about the course, we conducted an ANOVA for each item on the end-of-course evaluation. Adjusting for multiple comparisons, we found a statistically significant difference for two items. The first item asked, “How valuable was reflecting in learning logs in the course?” Post-hoc comparisons revealed that participants in the Instructor Support Online condition indicated that the logs were more valuable than did those teachers in the groups that had access to peer interactions via a discussion board. Given that teachers in the peer interactions groups were encouraged to record and discuss their thinking in the discussion board, it is logical that they would then find the learning log, in which they recorded similar thoughts, less valuable than did teachers who did not have access to a discussion board.

The second item asked, “How valuable was interaction with facilitators in the course?” Post-hoc comparisons showed that participants in the No Support condition rated the value of interactions with facilitators lower than did teachers in all other groups. Given that the coordinator for this condition was instructed not to have extended interactions with participants, did not have content knowledge expertise, and provided only short comments stating that a submitted assignment met the requirements for the course, it is not surprising that teachers in the No Support condition rated the value of interactions with the facilitator significantly lower than did teachers in the three other groups.

Changes in pedagogical beliefs. We designed the pedagogy survey to collect information about teachers’ pedagogical beliefs and practices. We administered the survey pre- and postcourse, and used the data to examine changes in teachers’ beliefs and practices that followed their participation in the course. Each of

the seven scales was standardized to have a mean of 0 and a standard deviation of 1. A comparison of precourse mean scores for each scale indicated that there were no significant differences among groups prior to the start of the course. Table 5 displays the mean scale scores for all participants for the pre- and postcourse administrations. The column labeled Post–pre displays the change in mean score between the precourse and postcourse administrations. As seen in Table 5, after adjusting for multiple comparisons, there were significant changes in teachers' responses between the pre- and postcourse administration for five of the seven scales (effect sizes for significant changes ranged from .47 to .86). Specifically, teachers' confidence in teaching mathematics, student-centered beliefs, belief that students should "do" the learning, and confidence in their mathematics knowledge and skills all experienced significant increases. The value placed on teacher-centered instructional practices experienced a significant decrease.

To examine whether changes in scale scores differed among the four groups, an ANOVA with post-hoc comparisons was conducted. No statistically significant differences were found among conditions in the amount of change for any of the pedagogical belief scales. That is, the increases appear to be comparable across conditions.

Changes in instructional practices. Teachers completed three teacher logs prior to the course and three logs following the completion of the course. As described above, the logs asked teachers to indicate the extent to which each type of activity was a component of the logged lesson. A comparison of precourse responses indicated that there were no statistically significant differences among groups prior to the course. Of the 23 instructional activities or behaviors included in the log, 10 items saw significant changes in the reported importance prior to and following the professional development course. As seen in Table 6, following the course, teachers reported decreases in having students work on or review homework during class, demonstrating concepts to the whole class, and addressing routine or textbook-based problems. Teachers reported increases in asking students to make conjectures, presenting an answer in words, asking follow-up questions to student responses, having students work in pairs or small groups, having students respond to each other, having students debate ideas or explain their reasoning, and having students work together on more extended complex problems. These changes are consistent with the intended effects the course was designed to have on instructional practices, suggesting that the course was effective in influencing teachers' practices.

To examine whether changes in practices differed significantly among the four versions of the course, we conducted an ANOVA for each item. There was a significant difference among groups for only one item. This item focused on the extent to which teachers reported leading whole-class discussions (but not presenting information to the whole class). For this item teachers in the No Support condition reported very little increase in this practice, whereas teachers in the three other conditions reported moderate increases. When we made adjustments for multiple comparisons, the difference among groups for this item was no longer statistically significant. Thus, based on teachers' instructional logs, all four versions of the course had similar effects on teachers' practices.

Table 6: Significant Changes in Instructional Log Activities and Behavior

Item	Teacher Log Questions	Pre			Post			Difference		
		N	Mean	N	Mean	N	Mean	Post- pre	<i>p</i> ¹	
2	I asked the students to make conjectures.	121	2.23	126	2.47	121	0.27	<0.001		
5	I asked students to present an answer to a problem in words.	122	2.22	126	2.39	122	0.17	0.009		
6	I had students work on or review homework.	122	1.93	125	1.74	121	-0.17	0.003		
8	I asked follow-up questions to students' responses to questions.	121	2.51	126	2.70	121	0.19	0.001		
10	I demonstrated/explained concepts to the whole class.	122	2.58	122	2.24	118	-0.33	<0.001		
11	I addressed routine or textbook-based problems.	122	1.95	122	1.67	118	-0.26	<0.001		
16	I had students work in pairs or small groups.	122	2.20	124	2.48	120	0.27	<0.001		
18	I had students respond to one another.	121	2.20	123	2.51	118	0.32	<0.001		
19	I had students debate ideas or otherwise explain their reasoning.	121	2.18	123	2.51	118	0.33	<0.001		
20	I had students work together on problems for which there is no immediately obvious method or solution.	121	1.66	124	1.98	119	0.33	<0.001		

1 p value for dependent t test = whether the difference between post and pre scores is significantly different from zero.

Student survey results. Prior to and following the professional development course, teachers administered a survey to their students that focused on instructional and learning activities students engage in during class. Table 7 (page 460) presents the items for which statistically significant changes (adjusting for multiple comparisons) in student responses occurred, whereas those items for which changes did not occur can be seen on the student survey available at the URL referenced above. Of 16 items presented to students, significant changes in student responses between the pre- and postcourse administrations occurred for six items. Two of these items—copying notes from the board and practicing problems similar to those the teacher shows students how to solve—saw significant decreases in reported use. Students reported increases in being asked to explain how they got their answers to problems, in working on math problems with classmates in class, in their teacher trying to understand a student’s approach to a math problem, and in working on an extended math problem during class. All of these changes are consistent with those reported in the teacher logs and with the intended effects of the course on teacher’s instructional practices. As students were unaware of the content of the course in which their teacher participated, the converging results in the student survey data provide confirmatory evidence regarding the accuracy of the teachers’ self-reports about change in their practices.

To examine whether changes in the instructional practices and activities that students reported experiencing or engaging in differed among groups, we conducted an ANOVA for each of the 16 student survey items. No significant differences were found among groups for any of the student survey items. This suggests that the changes in instructional practices and learning activities reported by students were similar across all four versions of the course.

Math assessment. To examine the effect that participation in the online professional development course had on teachers’ knowledge of teaching mathematics, teachers completed a pre- and postcourse math assessment that required them to analyze three samples of student work. Table 8 (page 461) displays the mean standardized total scores awarded across all teachers for the pre- and postcourse test administration. A comparison of precourse scores indicate that there was a statistically significant differences among groups for the set of items that focused on Patterns, with Group 3 performing better than the other groups prior to the course. There was not a statistically significant difference among groups for the Function item set. It is important to note that the Pattern item set is the only measure for which a statistically significant difference was detected among groups prior to the course across all measures collected for this study.

As seen in Table 8, scores increased on both tests for all teachers. With the exception of the function test score for Group 2, mean test scores also increased within each group on both tests. Only two score increases, however, were statistically significant, the mean Patterns test score for all participants (effect size = .46) and the mean Patterns test score for Group 2 (effect size = .78).

To examine whether changes in test scores varied among groups, we conducted an ANOVA for both the Pattern and Function test scores. No statistically significant differences in test score changes occurred among the four groups.

Table 7: Statistically Significant Changes in Student Survey Items

Item	Student Survey Question	Pre		Post		Difference		p^*
		N	Mean	N	Mean	N	Post–pre	
7	My teacher asks me to explain how I got my answers to math problems.	145	3.19	125	3.27	93	0.10	0.001
9	I work on math problems during class time with other students in my class.	145	2.74	125	2.81	93	0.10	0.007
10	My teacher tries to understand my way of doing math problems.	145	3.00	125	3.12	93	0.08	0.006
11	We copy notes from the board.	145	3.05	125	2.89	93	-0.15	0.001
16	In math class, we work on one big math problem for a long time.	145	2.14	125	2.22	93	0.12	0.001
17	My teacher shows us how to solve math problems and then we practice similar problems.	145	3.50	125	3.40	93	-0.13	<0.001

* p value for dependent t test = whether the difference between post and pre scores is significantly different from zero.

DISCUSSION AND SUMMARY

The study presented here examined the effect that different levels and types of supports for an online professional development course had on the intended learning outcomes. In the Highly Supported condition, participants worked through course readings and assignments as a group, were required to interact with their colleagues via a discussion board, and received support from both a content expert instructor and an online learning facilitator. In the Facilitated Peer Support condition, participants worked through the course as a group, interacting with each other via a discussion board, with process guidance from an online facilitator who did not have expertise in mathematics education instruction. In the Instructor Support Only condition, participants worked through the course material at their own pace and were not able to interact with

Table 8: Mean Score Change for Mathematics Understanding Test

Treatment Group	Pre		Post		Post-Pre	<i>p</i>	
	Mean	N	Mean	N			
Total	-0.30	60	0.17	66	0.46	<0.01	
Pattern	1. Highly supported	-0.43	12	-0.03	16	0.39	0.30
	2. Facilitated peer support	-0.66	17	0.13	17	0.78	0.01
	3. Instructor support only	0.28	15	0.31	17	0.03	0.94
	4. No support	-0.35	16	0.27	16	0.62	0.09
	Total	0.01	66	0.14	60	0.13	0.41
Function	1. Highly supported	0.26	16	0.03	12	-0.24	0.43
	2. Facilitated peer support	-0.13	17	-0.04	17	0.09	0.78
	3. Instructor support only	0.00	17	0.32	15	0.32	0.94
	4. No support	-0.08	16	0.26	16	0.34	0.39

other participants, although they did have interactions with both a mathematics instructor and an online facilitator. Finally, in the No Support condition, participants worked through the course at their own pace, were not able to interact with other participants, and had minimal interactions with a coordinator who did not have content expertise.

Overall, the course yielded positive effects on the intended outcomes across all four conditions. On average, teachers' pedagogical beliefs shifted to become less teacher directed and more student centered. Teachers strengthened their belief that students could do their own learning and became more confident in their mathematical skills and ability to teach mathematics. As reported by both teachers and their students, teachers' instructional practices also shifted in intended ways. On average, teachers decreased the use of worksheets and shorter problems. In addition, teachers increased the frequency with which they asked students to explain their thinking, write about mathematics, work with peers on extended problems, and discuss strategies for solving mathematical problems. Teachers also experienced some increases, albeit less pronounced, in their knowledge of mathematics teaching. On average, teachers' scores on the mathematics Pattern test increased significantly. Increases on the Function test, however, were not statistically significant. Overall, the results show that the 8-week online course was successful in enabling participants to achieve the defined learning goals, as was found in the prior study.

However, we also found that the unexpected outcome from the prior study was replicated, even with the addition of a stronger contrast between the Highly Supported and No Support conditions. As in the prior study, the positive effects

of the course did not vary across support conditions. For the mathematics test, the pedagogical beliefs survey, the student survey, and the instructional logs, we found no significant differences among the four versions of the course.

In addition, despite the dramatic difference in the supports available across conditions, teachers' ratings were generally consistent across the four versions. The two items for which responses differed significantly are easily explained: (a) Teachers who had peer interactions available found the individual learning logs less useful than those who did not have peer interactions available, as the use of these logs was somewhat redundant with the peer exchanges via the discussion board, and (b) Teachers in the No Support condition found interactions with the facilitator less valuable than teachers in all other versions of the course, as the types of interactions in which the facilitator engaged were intentionally limited in this condition.

The similarity of effects across the four versions is surprising given the emphasis in the literature on the importance of interactions among participants in online courses. Although substantial interaction occurred in the two high-interaction versions of the course, absolutely no interaction among participants occurred in the two low-interaction versions of the course. Yet the outcomes were nearly identical. Similarly, the literature emphasizes the importance of facilitation, but our results showed no differences in learning outcomes between conditions that were highly facilitated by both a content expert and an online learning facilitator and those that lacked one or both of these types of support. Given the large differences in the level of interactions among participants and the level of facilitation, these findings are particularly surprising. Moreover, the findings suggest that when a course is well designed and employs high-quality reading material and learning activities, the high levels of facilitation or interactions among participants may not be necessary to produce positive effects on teachers' pedagogical beliefs, instructional practices, and, to a lesser extent, understanding of mathematics teaching.

Although these findings replicate those from a prior study, they must be placed in the context of the study's limitations. First, the study focused on only one course delivered only to middle school mathematics teachers. Had a different course that focused on different types of teachers or different content been employed, the outcomes may have been different.

Second, all conditions of the course experienced considerable attrition. On average, 46% of the teachers who began a course did not finish the course or the required data-collection instruments. The fact that nearly half of the teachers did not complete the course may mean that the course either did not meet their needs or was too challenging for them. Although the characteristics of teachers who dropped out of the course did not differ among the four conditions, it is plausible that had these teachers persisted, different findings may have resulted.

Third, the course employed for this study was well designed and employed high-quality learning materials and activities. In addition, the course lasted for 8 weeks. For a course that is shorter in length or that employs materials of a lower quality, interactions among participants and the amount and type of

facilitation may provide valuable supplemental opportunities for learning. Thus, had this study employed a shorter course or a course that employed lower-quality materials and activities, different findings may have resulted.

Fourth, it is possible that the data-collection instruments were not sensitive enough to detect subtle differences in changes that occurred among groups in participants' beliefs, practices, and understanding. However, it is important to note that the instruments were sensitive enough to detect changes that occurred between the period when the instruments were completed prior to the course and following the course. Given that these changes were detected, it seems unlikely that a lack of instrument sensitivity is a plausible explanation for why changes among groups were not detected.

Finally, all of the participants in this course were volunteers who were likely to be highly motivated individuals who were sincerely interested in developing their algebraic teaching skills. In many cases, however, participation in professional development is required by a school or district. In such cases, some teachers may be less motivated and engaged in the learning. If presented with a self-paced version of the course, some of these teachers might be unmotivated to complete the reading and activities and may make a minimal effort when completing assignments. The resulting effects of the course might then be smaller.

Despite these limitations, this study provides preliminary evidence that a well-designed online course designed as a self-study with minimal interactions may be as effective as one that is highly interactive with both instructors and peer participants. Future studies may wish to explore this issue using different courses, content areas, and methods of recruiting teachers. Specifically, rather than recruiting teachers by asking them to volunteer to participate in the study, the potential effect of motivation might be limited by recruiting multiple school systems that want to implement professional development for all teachers and then manipulate conditions across teachers who are required to participate in the program. In addition, it would be informative to examine how the effects on the intended learning outcomes found in this study compare to the effects that occur in a face-to-face delivery format. It is clear, however, that an OPD course can have very positive effects on teachers' knowledge, pedagogical beliefs, and instructional practices, and that the magnitude of these effects may be invariant across different levels of facilitation and interactions when a course is well designed and employs high-quality learning materials.

Acknowledgments

The authors wish to thank their colleagues, Heidi Larson, Josephine Louie, and Amy Goldberg, for their contributions to this work. This material is based upon work supported by the National Science Foundation under Grant No. 0309401 to Education Development Center Inc. (EDC). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

Contributors

Michael Russell is an associate professor at Boston College's Lynch School of Education and Director of the Technology and Assessment Study Collaborative. (Address: 332 Champion Hall, Boston College, Chestnut Hill, MA 02467; E-mail: russelmmh@bc.edu)

Glenn Kleiman is executive director of the Friday Institute for Educational Innovation and professor of educational leadership and policy studies at the North Carolina State University College of Education. He was Vice President and Center Director at Education Development Center, Inc. (EDC) while the research reported in this article was conducted. (Address: 1890 Main Campus Drive, Raleigh NC 27606; Phone: +1.919.513.8509; E-mail: glenn_kleiman@ncsu.edu)

Rebecca Carey is a project director at the Education Development Center and is currently working for the Regional Education Laboratory for the Northeast and Islands. (Address: EDC, 55 Chapel Street, Newton, MA 02458; Phone: +1.617.618.2892; E-mail: rcarey@edc.org)

Joanne Douglas is a research associate at the Technology and Assessment Study Collaborative at Boston College. (Address: 332 Champion Hall, Boston College, Chestnut Hill, MA 02467; E-mail: jldouglas31@hotmail.com)

References

- Anderson, T., Rourke, L., Garrison, D. R., & Archer, W. (2001). Assessing teaching presence in a computer conferencing context. *Journal of Asynchronous Learning Networks*, 5(2), 1–17.
- Ball, D. L., & Cohen, D. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & L. Sykes (eds.), *Teaching as the Learning Profession* (pp. 3–32). San Francisco: Jossey-Bass.
- Becker, H. (1999). *Internet use by teachers: Conditions of professional use and teacher-directed student use*. Irvine, CA: Center for Research on Information Technology and Organizations. Retrieved December 10, 2008, from <http://www.crito.uci.edu/tlc/findings/internet-use/startpage.htm>
- Borasi, R., & Fonzi, J. (2002). *Professional development that supports school mathematics reform*. Retrieved November 25, 2002, from www.nsf.gov/pubs/2002/nsf02084/start.htm
- Cary, R., Kleiman, G., Russell, M., & Douglas Venable, J. (2008). Online courses for math teachers: Comparing self-pace and facilitated cohort approaches. *Journal of Technology, Learning and Assessment*, 7(3). Retrieved December 26, 2008, from <http://escholarship.bc.edu/jtla/vol7/3/>
- Darling-Hammond, L. & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform. *Phi Delta Kappan*, 76(8), 597–604.
- Dede, C. (Ed.). (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA: Harvard Education Press.
- Diaz, D. P. (2002). Online drop rates revisited. *The Technology Source*, May/June. Retrieved December 10, 2008, from <http://ts.mivu.org/default.asp?show=article&id=1034>

- Docherty, A., & Sandhu, H. (2006). Student-perceived barriers and facilitators to e-learning in continuing professional development in primary care. *Education for Primary Care, 17*, 343–353.
- Driscoll, M. (1999). *Fostering algebraic thinking: A guide for teachers, Grades 6-10*. Boston: Heinemann.
- DuFour, R. (2002). Taking on loneliness. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 24–25). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.
- Florida Instructional Technology Resource Center at UCF. (2000). *Online staff development: Lessons learned from developers, from facilitators, from participants*. Orlando, FL: Florida Department of Education Bureau of Educational Technology.
- Galley, M. (2002). E-training offers options. *Education Week, 21*(35), 41–44.
- Garrison, R. D., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *American Journal of Distance Education, 19*(3), 133–148.
- Ginsburg, A., Gray, T., & Levin, D. (2004). *Online professional development for mathematics teachers: A strategic analysis*. Washington DC: National Center for Technology Innovation, American Institutes for Research.
- Kleiman, G. M. (2004). *Meeting the need for high quality teachers: E-learning solutions*. A paper presented at the U.S. Department of Education Secretary's No Child Left Behind Leadership Summit (July 12–13). Available online at <http://www.ed.gov/about/offices/list/os/technology/plan/2004/site/documents/Kleiman-MeetingtheNeed.pdf>
- Lawless, K., & Pellegrino, J. (2007). Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575–614.
- National Foundation for the Improvement of Education. (1996). *Teachers take charge of their learning: Transforming professional development for student success*. Washington, DC: NFIE.
- National Staff Development Council. (2001). *E-learning for educators: Implementing the standards for staff development*. Oxford, OH.
- Nemirovsky, R., & Galvis, A. (2004). Facilitating grounded online interactions in video-case-based teacher professional development. *Journal of Science Education and Technology, 13*(1), 67–79.
- Richardson, J. (2002). E-learning potential: Online staff development has great possibilities – and pitfalls. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 12–13). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.
- Russell, M., O'Dwyer, L., Bebell, D., & Miranda, H. (2004). Technical Report for the USEIT Study. Chestnut Hill, MA: Technology and Assessment Study Collaborative. Available online at http://www.intasc.org/PDF/useit_r11.pdf
- Sargeant, J., Curran, V., Allen, M., Jarvis-Selinger, S., & Ho, K. (2006). Facilitating interpersonal interaction and learning online: Linking theory and practice. *Journal of Continuing Education in the Health Professions, 26*, 128–136.

- Sparks, D. (2002). Dreaming all that we might realize. In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 18–23). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.
- Sparks, D., & Hirsh, S. (1997). *A new vision for staff development*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Spicer, J. (2002). Even better than face-to-face? In A. Thorson (Ed.), *By your own design: A teacher's professional learning guide* (pp. 32–33). Columbus, OH: Eisenhower National Clearinghouse for Mathematics and Science Education.
- Stigler, J. W., & Stevenson, H. W. (1991). How Asian teachers polish each lesson to perfection. *American Educator*, 15(1), 12–21, 43–47.
- Treacy, B., Kleiman, G., & Peterson, K. (2002). Successful online professional development. *Leading & Learning with Technology*, 30(1), 42–47.
- Whitehouse, P. L., Breit, L. A., McCloskey, E. M., Ketelhut, D. J., & Dede, C. (2006). An overview of current findings from empirical research on online teacher professional development. In C. Dede (Ed.), *Online professional development for teachers: Emerging models and methods* (pp. 13–29). Cambridge, MA: Harvard Education Press.
- Yang, S. C., & Liu, S. F. (2004). Case study of online workshop for the professional development of teachers. *Computers in Human Behavior*, 20, 733–761.