Measuring Feature-Level Participation and Efficacy with Online Teacher Professional Development (oTPD)

BY

JEREMY RIEL
B.A., University of Oregon, 2007
M.A., Georgetown University, 2012

THESIS

Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Educational Psychology
in the Graduate College of the
University of Illinois at Chicago, 2020

Chicago, Illinois

Defense Committee:

- Kimberly A. Lawless, Chair and Advisor
- Michael K. Thomas, UIC Educational Psychology
- Yue Yin, UIC Educational Psychology
- Scott W. Brown, University of Connecticut
- Lisa J. Lynn, Chicago Public Schools

Dedicated to Jessica and Josephine

ACKNOWLEDGEMENTS

I would like to foremost thank my wonderful dissertation committee as a group for their unwavering support, advice, and encouragement, especially as we were required to move the dissertation journey to uncharted lands as a result of the global COVID-19 pandemic. With virtual life becoming the norm during this difficult time, it is timely that this dissertation explored the features of online educational platforms and remote work. During the final drafts of this dissertation, I appreciate the committee's challenges to think about the implications that this study and future work can have to improve the world's educational systems in my own small way.

To James Oren, I wish to extend my gratitude for helping me with the HLM portions of the study, including figuring out how to get the R code to work and conform the software to the existing datasets - even if I already offered a cast iron pot full of chili dinner to show my thanks.

To Michael Thomas, I want to say thank you for your friendship and always-optimistic support over the last few years. I admire the depth of your brilliance and having the ability to bounce between pop culture memes, research ideas, and playing games whenever we visit. I look forward to playing and making hundreds of games, apps, and research papers with you in the future.

To Yue Yin, I want to thank you for your continued interest in my online education research. You have always asked me useful and practical questions that have helped drive the questions I have asked over the years about online learning, analytics, and finding out what works and why.

To Scott Brown, I have really appreciated our friendship and your guidance over the many years that I have been a part of the GlobalEd team. I want to thank you for taking me in and giving me a chance, co-writing papers with me, and for your many years of experience and advice that you have so willingly shared with me and your other graduate students. And, thank you for teaching me that every lesson in life can be distilled down to examples involving Indiana Jones or Yoda.

To Lisa Lynn, thank you for being with me every step of the way through the graduate experience – from starting in LS 501 together when we were tying knots, to being coworkers, to you having crossed the finish line first and generously extending your hand from the other side to help me get across myself. I have valued each of your contributions, thoughts, and ideas that you had during the dissertation process and my broader research work.

To Kim Lawless, I certainly wouldn't have been able to do this without your ongoing support, continued encouragement, and even prodding to tinker, think outside the box, and do my best. I will forever be grateful to you for bringing me into the family. I hope to continue working with you for years to come to invent high-impact ways of learning using digital tools. Thank you for tolerating my tendencies to wizard up a solution to a problem and ask for forgiveness later!

Finally, but most importantly, to Jessica and Josephine, thank you for the unending support of my research and graduate schoolwork. Your tireless encouragement and accompaniment on this journey have kept me grounded and remembering what all the work is for. Our journey has been a fun one thus far, and I am excited for what the next adventures have in store for our family.

JJR

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SUMMARY

Over the last three decades, there have been substantial advances in the literature on understanding the essential design principles and necessary features of teacher professional development (PD) programs to support implementation of new curricula and standards. However, although there is a consensus in the research community on the design principles for PD programs, the field also lacks evidence on the specific technologies, media, and strategies for implementing professional development design principles in an effective way.

To address this gap in the literature, this dissertation investigated the design of an online teacher professional development (oTPD) program focused on supporting teachers' voluntary first-time implementation of a novel curriculum called GlobalEd, and whether this program had any effect on both teachers' implementation adherence and subsequent student achievement. The PD program was analyzed at the feature level by measuring the degree to which each design feature in the PD was used by the participating teachers (n = 41 teachers). To examine whether participation in PD features predicted teachers' adherence to curriculum implementation tasks, OLS regression models were used to identify that more "active" PD design features that encouraged mindful participation, like message board discussions and generating written projects were found to have a positive predictive effect on curriculum adherence. Conversely, passive media features like email reading and video watching were found to not have any effect in predicting adherence. Finally, hierarchical linear models (HLM) with students nested within teachers' classrooms were used to investigate whether teachers' participation in PD features had a predictive effect on student achievement (n = 773 students).

No significant predictive effects were observed on both PD participation or adherence on student achievement. As a result, this dissertation provides direct evidence on the efficacy of specific implementation media and technologies that map to long-standing accepted PD design principles. Commitments to design principles that emphasize active learning and relevance to practice are specifically supported. In addition, this dissertation emphasizes the necessity of researchers' mindfulness of data grain size and the importance of conducting basic research in teacher professional development to ensure that meaningful effects of PD can be observed.

CHAPTER 1: INTRODUCTION

In recent years, several large-scale local, state, and federal educational reforms in the United States have been implemented with the intent to improve student achievement. Developed in response to both shifting political interests and to reflect advancements in educational research, the implementation of new curricular initiatives and student progress standards have become commonplace occurrences for teachers, school administrators, and students alike (Cohen, Raudenbush, & Ball, 2003; Darling-Hammond, Bae, Cook-Harvey, Lam, Mercer, Podolsky, & Stosich, 2016; Slavin, 2002). In what has been called the "accountability context" of formal education, teachers have become increasingly responsible for and are a critical component of the implementation of such reforms in the classroom (Barab & Luehmann, 2003; Guskey, 2005; Hochberg & Desimone, 2010; Timperley & Alton-Lee, 2008).

Because of the trend in teacher accountability toward reform implementation, teacher performance has been increasingly linked to student outcomes in recent years. This is well-evidenced in modern large-scale policies such as the federal No Child Left Behind Act (2001) and the Every Student Succeeds Act (2015). These federal policies (1) formalized connections between student achievement and teacher performance, as typically evidenced through student standardized test scores; (2) recognized the need for teacher support in order to meet policy-based accountability measures; and (3) prioritized teacher professional development toward the implementation of educational reforms (Johnson, 2007; Linn, Baker, & Betebenner, 2002). Teachers, however, are not only influenced from directives at the federal level. Alongside federal initiatives, individual states have also collaboratively developed and adopted large-scale educational standards, such as the Common Core State Standards and the Next Generation Science Standards (Porter, McMaken, Hwang, & Yang, 2011; Pruitt, 2014; Reiser, 2013).

Perhaps most frequently, teachers are typically expected to implement curricula and standards at the state, local district, and school levels as well, which represents a complexity of performance requirements at various levels that teachers must increasingly navigate and master (Darling-Hammond & Bransford, 2007). Because of this, teachers are additionally responsible for developing their professional skills to meet the expectations of various overlapping initiatives and policy requirements in today's educational contexts (Hochberg & Desimone, 2010).

The increased emphasis on teacher accountability procedures and on the implementation of new curricula and standards in ways that meet the intended outcomes of instructional designers and policy makers has led teachers to rely on ***professional development (PD)*** programs to support their enactment of curricular and standards initiatives (Fishman, Marx, Best & Tal, 2003; Hochberg & Desimone, 2010; Leithwood, Steinbach, & Jantzi, 2002). Formal PD programs are now commonly seen as a necessary approach to both developing teachers' abilities for enacting new curricula and standards and to support teachers' everyday learning as professional practitioners (Desimone, Porter, Garet, Yoon, & Birman, 2002; Guskey, 2000). Although only a few large-scale studies have been published to date, teacher participation in professional development programs that support teachers' enactment of initiatives has consistently been positively related to student achievement (Garet et al 2001; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Marzano 2007). However, PD is not only solely focused on student success, but also on promoting positive changes and growth in teacher daily practice as participants in a professionalized career.

Researchers and instructional designers have recently argued for the need for PD initiatives that develop teacher skill in student-centered pedagogical approaches that have been shown in research to be positively related to student achievement, including problem-based learning pedagogies (Ertmer & Simons, 2006; Walker, Recker, Robertshaw, Osen, Leary, Ye, & Sellers, 2011), constructionist approaches to learning (Laurillard et al., 2011; Ostashewski, Reid, & Moisey, 2011), and inquiry-based learning strategies (Akerson & Hanuscin, 2007; Wee, Shepardson, Fast, & Harbor, 2007). Similarly, teachers additionally need to be supported in their ongoing development of skills for teaching with emerging technologies, such as facilitating blended learning opportunities in classrooms and other online learning environments (Baran & Correia, 2014; Oliver & Stallings, 2014; Wilson & Stacey, 2004). Pre-service teacher preparation programs can only be expected to prepare candidates to a certain point, as many of a teacher's skills are developed as a result of their time "in-service," or via direct classroom experience and personal growth activities as they move from being a novice to an expert in the profession (Ball & Cohen, 1996; Hammerness, Darling-Hammond, Bransford, Berliner, Cochran-Smith, McDonald, & Zeichner, 2005). To this end, PD initiatives are useful approaches to improve teacher skills during their everyday practice so they can be better prepared to enact new curricula and standards as they are intended by instructional designers and researchers.

However, it has been historically difficult to implement PD in a systematic, sustained way to support large-scale reforms and to subsequently identify if such PD interventions were effective at achieving intended goals (Borko, 2004; Desimone, 2009; Penuel et al., 2007). Although positive effects have been observed in various studies, the overall body of evidence regarding what parts of PD programs are effective remains underdeveloped in the field (Wayne, Yoon, Zhu, Cronen, & Garet, 2008). The financial costs associated with design and implementation, travel requirements of participants, and delivery of PD programs at scale have all traditionally constrained the offering of quality PD programs, especially those that operate in an ongoing fashion (Marrongelle, Sztajn, & Smith, 2013). Many PD designs reported in the literature have historically relied on face-to-face interaction, which is typically only feasible to complete at the local school level (Dede, 2006). Since the availability of consumer-level Internet access in the early 2000s, instructional designers and policymakers have been increasingly moving toward offering ***online teacher PD (oTPD)*** opportunities to support teachers' work. oTPD opportunities have the unique potential to provide more personal and relevant experiences for teachers and to address the logistical challenges posed by face-to-face PD (Lieberman & Mace, 2010; U.S. Department of Education, 2010).

Singular, short-term PD programs have been a common design for teacher professional learning in the last three decades. Short-term trainings indeed have value for some professional learning purposes, such as initial training on new curricula to gain familiarization and learn the proper steps of implementation, or to gather information on new topics or skills. However, in recent years, oTPD programs have demonstrated strong potential for promoting robust participant interaction and personalized activity for longer periods of time than traditional "one-shot" or up-front PD seminars and workshops of the past (Dede et al. 2009; Vrasidas & Glass, 2004). With advances in interactive digital technologies over the last decade, oTPD program designs can support teachers' ongoing implementation of new curricula over time, address teacher challenges as they arise during authentic classroom experience, and build teachers' skills in novel pedagogies (Fishman, Konstantopoulos, Kubitskey, Vath, Park, Johnson, & Edelson, 2013). This includes teachers having greater choice in how and when their time is spent on PD activities, the ability to communicate and share information asynchronously, and to interact with other people regardless of geographic distance and, sometimes, language (O'Dwyer, Carey, & Kleiman, 2007; Vrasidas & Glass, 2004). In the case of implementing new curricula and standards, ongoing oTPD programs can also allow teachers to try new skills without having to memorize all of the content from a single training, for instructional designers and policymakers to appropriately support teachers when new initiatives are being implemented, and for teachers refine their practice as they perform their everyday work (Fishman et al., 2013; Squire, MaKinster, Barnett, Leuhmann, & Barab, 2003). As a result, shared participation between researchers, instructional designers, and teachers in long-term and ongoing oTPD programs will likely become a common aspect of teachers' everyday practice in years to come.

To support the development of research-based PD programs, scholars have largely reached a consensus on the various processes that are involved with teachers' professional learning (Borko, 2004; Desimone, 2009; Hawley & Valli, 1999). However, despite widespread agreement on the theories and design principles are involved with professional learning, general reviews of PD research have consistently shown that there is little empirical evidence that has been provided in the literature over the last two decades to justify broad claims on what designs constitute effective professional development (Dede et al. 2009; Lawless & Pellegrino, 2007; Wayne et al., 2008). Additionally, there remains a lack of a widely accepted framework from which designs or implementations of PD programs can be generated from these theoretical principles (Hawley & Valli, 1999; Rice & Dawley, 2009). Choices related to the implementation of design principles include questions such as the selection of how interactivity will occur within a PD program, when activities should be employed to meet certain goals, and the specific technologies and tools to be used in an intervention. Online technologies afford substantial flexibility to participants in which each participant's experience can be unique and highly personalized, leading to additional research challenges for demonstrating causal mechanisms of PD programs that lead to positive outcomes. Therefore, although there is consensus on what general features should be present in PD interventions, the field lacks an *implementation* *consensus,* or a consensus on the specific approaches and technologies used in PD, among the research community on how to exactly enact PD interventions with different contexts and technologies (Rice & Dawley, 2009).

As a result, the lack of a PD implementation consensus among the research community has subsequently lead to systematic challenges with the research of PD interventions, specifically with examining the efficacy and theoretical basis of PD programs. Additionally, oTPD research is still relatively new in the field of teacher professional development, leading to challenges in identifying salient research trajectories for the field. Only two substantive reviews on online or technology-based PD have been conducted, which were published almost a decade ago (Dede et al., 2009; Lawless & Pellegrino, 2007). Both studies found that the field has significant gaps in performing research on oTPD program effectiveness to determine whether programs or their features actually work in authentically deployed contexts. Other studies reflecting on the field of PD research have identified that peer-reviewed articles often lack specification in their design features from which to reliably compare interventions, as well as exhibit varied foci, study scales, variables, or outcomes (Marrongelle, Sztajin, & Smith, 2013; Wayne et al., 2008). Because of a substantial variation in research foci and approaches, scholars have recently published multiple arguments for consolidating the field's research agenda for both online and conventional teacher PD and for better specifying the approaches to research that should be employed (Borko, 2004; Dede et al., 2008; Desimone, 2009; Hochberg & Desimone, 2010; Lawless & Pellegrino, 2007; Wayne et al., 2008). Most notably, PD research, as a field, needs better links between PD interventions, teacher learning outcomes, and student achievement outcomes to investigate whether PD has any ultimate effect on students and to ensure that investments in PD are meeting their goals (Hochberg & Desimone, 2010; Fishman et al., 2003).

If policymakers and instructional designers continue to agree that (1) teachers are increasingly accountable for the implementation of curricular and standards reforms and (2) that teachers need systematic support to assist with enacting these initiatives, then the responsibility for the successful implementation and rigorous evaluation of curricular interventions is also extended to the instructional designers of curricular interventions (Guskey, 2005).

1.1 Statement of the Problem

Educational policies have increasingly charged teachers with the responsibility of implementing new curricula and standards. Historically, PD has been the primary mechanism by which teachers are supported to carry out this charge (Guskey, 2005). In support of this, the PD research and design communities need robust evidence as to "what works and why" in PD (Borko, 2004; Desimone, 2009; Lawless & Pellegrino, 2007). In particular, because of the significant advances in digital technologies over the last decade, it is especially important to identify what works and why that with PD that is provided online (e.g., oTPD) (Dede et al., 2009). However, because oTPD programs employ digital functionality that allows users to create custom and personalized experiences, it cannot be assumed that every participant will experience oTPD in the same way. The potential for variation in the amounts and quality of participation within oTPD highlights the insufficiency of PD program efficacy investigations that conceptualize program participation as a "black box," or where program participants are regarded as having the same experience or are included in uniform experimental conditions within studies (Wayne et al., 2008). In addition, as oTPD programs are each implemented with a unique combination of individual features that are intended to realize specific goals, it is also no longer sufficient enough to conceptualize PD efficacy research as "single program." Instead, studies of program effectiveness should investigate the effects of each main design component of a PD program in order to determine the elements that ultimately exhibit the desired effects of teacher participants and PD designers (Borko, 2004; Desimone, 2009; Hochberg & Desimone, 2010). A survey of the previous oTPD research reveals that rigorous oTPD efficacy investigations should account for both the teacher and student effects of programs, as well as teachers' level of engagement with individual oTPD features. The findings from such studies can be used to reliably compare oTPD programs and their designs, generate new research trajectories, and inform future revisions of design features in oTPD programs based on empirical evidence and continual testing and refinement of the theoretical processes that are assumed to be present in the oTPD.

1.2 Goals of the Study

After presenting a discussion of essential definitions (Section 2.1), this dissertation begins with a two-part background survey on the current state of the oTPD research landscape (Section 2.2). In the first background section, a framework is proposed for evaluating oTPD programs in ways that correspond with the needs expressed by the research community for the conduct of rigorous, valuable investigations that can inform design of and investment in PD programs. In this survey, three focal areas for PD research are identified, which include (1) the structural elements and design features that are present in oTPD programs, (e.g., intended goals, design features, duration); (2) the design of oTPD research studies (e.g., focus of research, how participant experience has been measured); and (3) the units of analysis and variables of interest on which oTPD studies have focused in recent years. These focal areas allow for investigating key areas of oTPD programs that have been determined as critical for continued success in the field, for which reliable evidence is needed to advance the field's understanding of "what works and why" (Lawless & Pellegrino, 2007).

In the second part of the background section (Section 2.3), recently published oTPD literature from 2007 to 2017 is systematically reviewed based on the three focal areas that address the research concerns and constraints raised by the oTPD scholarly community. To better understand the current state of the field, a review of the literature is valuable for highlighting important areas that have been understudied by the field and can suggest new trajectories for research based on both the field's previous research and new trends in oTPD technologies from the previous decade. This review of the oTPD literature over the previous decade indicates that studies that the collective field has produced few scholarly works that investigate the efficacy of oTPD programs, which includes only a handful of studies that are present in the literature that investigate how oTPD programs influence both teacher practice and student achievement. In other words, the field has little knowledge as to what design elements work about oTPD toward promoting student achievement.

In most oTPD studies from the previous decade, formally reported analyses did not typically include the the identification of the degree to which teachers used individual oTPD features. Such a lack of research on the degree to which oTPD programs were used or experienced by teachers is problematic. If indeed online oTPD programs are becoming more open-ended and flexible, researchers and designers will increasingly need to know the degree to which teachers *actually use* oTPD features in order to rigorously determine whether features had any effect (Hochberg & Desimone, 2010; Wayne et al., 2008). In addition, testing whether individual design features were used helps to test and provide evidence for the continued use of the underlying theories and "chains of logic" upon which features are built (Wayne et al., 2008).

Therefore, it is no longer sufficient to assume that PD experiences are equal across all participants, as online experiences increasingly afford unique combinations of interactions (Dede et al., 2009).

Guided by the three-focus evaluatory framework and review of recent oTPD literature, the study presented in this dissertation (Sections 3-4) consists of an investigation of a previously implemented oTPD program's effectiveness at ultimately promoting student achievement through teacher development. To investigate teacher participation at the oTPD feature level, this study employs oTPD participation metrics that have been alluded by researchers in the field but have not been repeatedly represented in the literature. These participation metrics represent participant interaction with each online design feature of the oTPD program and are operationalized to provide insights on the varying levels of use of the oTPD program by teachers and to account for teachers' exposure to the oTPD program. Accounting for participation with individual features of oTPD in relation to the attainment of desired program outcomes can also provide valuable theoretical knowledge to the field about professional learning processes through the comparison of individual design features' operations in comparison to theoretically expected outcomes of features.

Highlighted as a critical need by researchers in the field, such an investigation of oTPD programs at the "feature level" will allow researchers to gain valuable insights about how oTPD design features are used and which elements of oTPD programs are important toward achieving intended outcomes. As each design feature in an oTPD program is designed to integrate known theories and processes of professional learning, the investigation of the feature-level variations in participant experience additionally provides researchers with an excellent opportunity to test whether features operate in the ways that researchers expect based on the theories upon which features are designed.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

2.1 Perspectives and Definitions of Professional Development

Historically, *teacher professional development* (PD) has been simply defined as the delivery of and participation in one-time, single, or "one-shot" training programs for teachers to improve skills, knowledge, and beliefs (Guskey, 2000; Monahan, 1996; OECD, 2009). In what have also often been called training, courses, workshops, or institutes, PD programs to remedy specific challenges being faced by teachers or to support the implementation of curricular initiatives have been provided by local education authorities, higher education institutions, and third parties outside of schools (e.g., educational technology vendors) (Goodall, Day, Lindsay, Muijs, & Harris, 2005; National Academies of Science, 2005). From this perspective, PD interventions and their associated content have conventionally been seen as experiences for teachers with which they attempt to gain specific required classroom knowledge, skills, and beliefs, continuing education credits, and other certifications to meet district requirements or fulfill personal needs (Guskey, 2000).

Although one-time PD programs have been the most frequent form of PD, the content of such programs is often challenging for teachers to integrate into their practice. Specifically, the topics and materials of one-time programs is often abstract and presented in a one-size-fits-all way, which, consequently, has often lacked connection to teachers' everyday classroom practice (Ball & Cohen, 1999). Additionally, PD is frequently limited in scope and duration and provides limited potential for ongoing teacher interaction and learning after the conclusion program, which can lead to separation between the PD content and the teachers' specific classroom practices and student needs (Guskey 2000).

To address this challenge, a growing number of organizations, policymakers, and scholars have forwarded long-term definitions of PD that considers PD activities as a process and not a single-instance, resulting in ongoing learning that spans the entire career. For instance, the definition for PD forwarded by the National Staff Development Council (NSDC, n.d.) focuses on the ongoing nature of professional learning as “a comprehensive, sustained and intensive approach to improving teachers' and principals' effectiveness in raising student achievement” (NSDC, n.d., n.p.). From a similar perspective, Diaz-Maggioli (2004) states that “Professional development can be defined as a career-long process in which educators fine-tune their teaching to meet student needs” (p.5). Alternatively, Zepeda (2013) argues that effective PD should be “research-based, tied to standards, and present a coherent structure for teachers to work in an environment in which the work of teaching is rooted in learning” (p.8). The emphasis by Zepeda that the “work of teaching is rooted in learning” suggests that although PD initiatives are often thought of as singular activities for specific goals, they are a part of a long-term process of professional growth. For this to work with the growing paradigm of PD-as-a-process emphasizes that for PD to be effective, PD activities for curriculum implementation should be integrated into a teacher’s everyday work, be connected to a long-term and sustained process of professional development for the teacher, and relate to authentic classroom contexts (Ball & Cohen, 1999).

In a reflection of this changing perspective on PD, recent federal policies have also recognized the ongoing, long-term nature of PD. For instance, The Every Student Succeeds Act of 2015 (ESSA) defines PD as:

> “...an integral part of school and local educational agency strategies for providing educators … with the knowledge and skills necessary to enable students to succeed in a well-rounded education and to meet the challenging State academic standards; and are

> sustained (not stand-alone, 1-day, or short term workshops), intensive, collaborative, job-embedded, data-driven, and classroom-focused" (p. 129 STAT. 2096).

This definition within the ESSA reflects the recent policy shift in focus on providing PD and serve as a primary example of the increasing nation-wide recognition for PD programs that both meet teachers' immediate and long-term continuing education needs. As PD being increasingly recognized as a part of an ongoing process of learning over a teacher's entire career, formal PD interventions are useful toward meeting these ends if such programs can sufficiently connect to teachers' ongoing practice and provide ample opportunity for both learning of material and that can be directly integrated into practice (Anderson & Herr, 2011; Kennedy, 2016). It is through the design and participation in PD programs that policymakers, researchers, and teachers can directly impact positive outcomes as a part of the ongoing professional learning process. This review is concerned with individually designed, singular professional development *programs* and the evaluation of the efficacy of these programs toward meeting their specified goals.

2.1.1 Defining Teacher PD Programs and their Characteristics

As illustrated above, two competing perspectives exist regarding the scope of professional development. Therefore, is useful for any evaluation of PD programs to specify the elements of what constitutes a PD program as a single unit, as it can be distinguished from the career-long, ongoing process of professional learning. Despite variations in their design, researchers have suggested that singular PD programs share common characteristics that distinguish them as measurable events within a teacher's history of learning over the span of a career. Most notably, single PD interventions exhibit design choices that can be used to specify, describe, and categorize programs. For instance, Fishman and colleagues (2003) suggest that there are four primary criteria that are used to qualify or describe a PD intervention: (1) there are content goals to be shared with teachers, (2) there is a strategy or pedagogy used with which participants are expected to interact, (3) there's a site at which interactions occur, and (4) there are media choices made by designers to communicate the content goals of the PD. Similarly, Lawless and Pellegrino (2007) suggest that PD programs can be categorized through their (1) content, (2) delivery mechanism, (3) duration, and (4) support mechanisms by which participants get assistance from facilitators. What is clear from these approaches is that PD programs employ *a priori* decisions to create a designed experience for teachers and goals and activities are generally defined. To address the need for distinguishing what actually constitutes a PD program when doing research on PD, Guskey (2000) offered three essential qualities that characterize individual professional development initiatives as interventions designed for specific purposes in which there are defined modes of interaction: interventions are (1) intentionally designed; (2) part of an ongoing process; and (3) systematic. These three qualities set apart PD interventions from other processes of professional learning and allow researchers to reliably investigate program efficacy and compare programs with each other. In addition, the three qualities forwarded by Guskey have been consistently affirmed by PD scholars as useful areas of focus regarding PD research.

First, Guskey states that PD interventions are *intentionally designed,* in that their design will "begin with a clear statement of purposes and goals" (2000, p.17). Alternatively stated, PD programs are interventions that are intended to achieve certain outcomes for teachers (e.g., implementation of curriculum, change in teacher practice, student achievement). Goal specification is important, as it is the first step in laying out a model or framework for PD design that will use theory and interactions to affect teacher change and student achievement (Wayne

Yoon, Zhu, Cronen, & Garet, 2008). Without specified, intentional goals, PD designers are lost as to what to implement and how to define success (Rice & Dawley, 2009). In addition to the PD program having intentional goals, participation by teachers is also not accidental. Teachers decide to participate in PD based on the knowledge of what they are to gain from it, and the PD program can be evaluated based on achievement of these goals (Conzemius & O'Neill, 2009; Todnem & Warner, 1994).

Second, Guskey argues that PD programs are *ongoing*. This is not to say that one-shot, or single timeframe PD programs are not appropriate for the ongoing nature of PD, but instead that professional development is indeed a part of an ongoing process of learning and practice by which the educator professional continually develops over their career. This specification challenges researchers and designers of PD interventions to question how the PD intervention fits in the overall process of teacher learning and how it is aligned and contextualized with a teacher's work. In fact, teachers often participate in multiple short-term PD programs over the course of their career as a part of the ongoing aspect of their development (Borko, 2004; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Teachers also frequently participate in multiple systematically designed, but informal professional development initiatives, such as through the participation in various communities of practice (Barab, Kling, & Gray, 2004; Booth & Kellogg, 2015; Wenger, 1998), self-initiated personal and professional learning network development and participation (DuFour & Eaker, 1998; Marcia & Garcia, 2016; Tour 2017; Trust, Krutka, & Carpenter, 2016), and school-based PD initiatives and learning groups (Darling-Hammond, 1994; McLaughlin & Talbert, 2006; Youngs & King, 2002). Whatever the duration of the PD, the program should recognize the need to fit into teachers' long-term learning trajectory and promote teachers' integration of the PD program goals into their practice. To this end, Kazemi and Hubbard (2008) suggest that PD is a "give and take" process that moves back and forth between practice and participation in PD interventions, regardless of how much time is spent in a single PD program - it always must connect back to practice somehow to have an effect. Regardless of their time frame, PD interventions are a critical part of a professional's long-term learning interests and goals. As a result, one single PD program is an important part of achieving specific goals within an ongoing process of learning.

Third, Guskey states that PD interventions are *systematic* in their approach to promoting professional learning. PD programs should be methodical, planned, designed with learning theory, adopt a specified approach to meet goals, and are systematically structured in a way that each element is designed to play a role in teacher learning (Guskey, 2000). In effect, the design decisions made by PD designers reflect a chain of logic in which theories of teacher change are embedded (Putnam & Borko, 2000; Wayne et al., 2008). The systematic nature of PD allows for both the individual design features and the PD as a whole to be evaluated for their efficacy and to know what elements work well or don't work well when used (Desimone, 2009; Hochberg & Desimone, 2010). This process requires specific decisions on part of instructional designers of the PD to implement features that are expected to lead to teacher learning and student achievement (Wayne et al., 2008).

Therefore, based on the above discussion, it is evident that a number of criteria can be used to specify PD and oTPD programs and interventions. For the purposes of this study, ***teacher professional development*** **(*PD*)** is defined as *any systematically designed activity or activities in which more than one teacher participates to meet intentionally established, measurable goals for ongoing learning and skill development related to teachers' practice*.

It is important to note that most PD studies likely do not achieve all the criteria in this definition, at least in how they are reported in the literature. However, the above definition presents distinct criteria that categorize designed PD efforts from those that are impromptu, informal, or a part of a teacher's unintentional everyday professional learning. Even if not reported in a study, the systematic nature of PD design assumes that choices were made by the designers regarding the theory, pedagogy, activities, interactions, and media that are expected to bring about positive outcomes for participants. Self-initiated PD and self-learning activities are thereby generally not considered to be a PD *program*, as there is usually a lack of systematic design, as well as other participants with which to interact. This definition does not preclude teachers from designing PD interventions, or those programs in which teacher participation in design or teacher-led efforts are sought out. Instead, other parties, such as curriculum providers, school districts and states, and technology vendors, have historically been the providers of systematically designed PD interventions and are the most commonly seen originators of designed PD programs.

2.1.2 Defining Online Teacher Professional Development (oTPD)

Of specific concern in this study are *online teacher professional development* (oTPD) programs. As a subset of general teacher PD, oTPD has emerged over the last two decades as a popular approach to expanding the geographic reach and interactivity of PD. For example, in their large-scale comparison study of face-to-face with online PD delivery, Fishman and colleagues (2013) define oTPD as "teacher learning experiences delivered partially or completely over the Internet, [which] can potentially provide high-quality teacher learning experiences" (p. 427). As the first of its kind, Dede (2006) edited a volume with descriptive and technical reports of innovative oTPD interventions and discussed oTPD as a new form of PD delivery with great promise. However, a formal definition of oTPD was not given in this volume, leaving the “online” component of PD to be flexibly interpreted. Although the word “online” simply implies PD that is conducted over the Internet, the term has become more complex within the broad variety of interactions that are possible in digitally mediated learning ecosystems available in 2017. To this end, a formal definition has become necessary in order to rigorously evaluate PD program efficacy, with oTPD programs included.

Although oTPD shares multiple similarities with other forms of teacher PD, such as face-to-face PD and use of digital media, oTPD designs are characterized by their use of internet-connected platforms or portals to host interactions using common computing devices. An important distinction can be made in light of modern reliance on digital technologies that oTPD does not necessarily mean only technology-based or use digital media, but instead that a connection to the Internet is required for participants to interact with other participants, program facilitators, and interactive computer applications. Toward this interpretation, Vrasidas and Glass (2004) contend that the distinguishing feature of oTPD is not necessarily the “online” component, but instead a degree of connectivity with other participants. From another perspective, Fishman and colleagues (2003) argue that the “site of interaction” is an important criterion for defining PD interventions. To this end, the primary site of oTPD is ostensibly “on the internet,” or that interactions that occur via networked technologies. Although this specification seems obvious, it has become increasingly less clear *where,* or, using Fishman and colleagues’ term, *at what site,* professional learning interactions occur. From yet another perspective, O’Dwyer, Carey, and Kleiman (2007) characterize oTPD through its potential to address issues of logistics, scheduling, and distance. To challenge matters further, the categorization of oTPD interventions has become more complex with the advent of ubiquitous computing and handheld devices, human-computer interactions (e.g., chatbots), the proliferation of public wifi and mobile data networks, and almost universal broadband internet access. Along with these developments, new hybrid models of PD have also become popular, such as blended learning PD opportunities and face-to-face PD interactions that use virtual tools. It is then important for studies on oTPD to distinguish at what point the interactions in a PD program define it as oTPD.

Therefore, as a subset of PD, **online teacher professional development (*oTPD*)** in this dissertation as the following: *any PD intervention [as defined above] within which a substantive degree of participant interaction requires internet-connected technologies.*

Because of the rapidly occurring advances in internet-based technologies and the changes in interaction potential that they afford, it may be necessary to return to the definitions used by the field in the future. This continual revaluation would ensure that the definitions continue to work well for specifying PD and oTPD interventions in order to provide the best evidence for program efficacy.

2.2 The oTPD Research Agenda: Necessary Elements of PD Efficacy Research

Since 2000, researchers have forwarded multiple arguments toward establishing a community-wide research agenda to both meet the immediate PD needs of teachers as they implement new curricula, technologies, and pedagogies, as well as to provide the field with rigorous evidence of effective PD approaches. To this end, many theoretical and methodological suggestions have additionally been issued by scholars for the future conduct of research and intervention design in PD in general and oTPD specifically. In the broadest sense, the research community primarily holds that PD studies must meet certain guidelines for program structure, research design, and journal reporting in order to provide the field with evidence of both what works in PD and why it works (Borko, 2004; Hill, Beisiegel, & Jacob, 2013; Lawless & Pellegrino, 2007; Wayne et al., 2008). In her seminal paper on the state of PD research, Borko (2004) argued for the need for better specification of both the design of PD programs and their associated research approaches in published papers in order to move toward research that can answer whether PD works at a larger scale. She further argues that this level of specification is additionally necessary to investigate PD programs at both the individual teacher and program levels. As a result, systematic, rigorously designed, and multi-lensed research approaches in studies would provide the field with sufficient evidence to understand if and how PD interventions work in a scaled, distributed way (Dede et al., 2009). This sentiment is echoed more recently by Marrongelle, Sztajn, and Smith (2013), who suggest that as large-scale reforms continue to be implemented across the United States, particularly through online media, PD interventions need to be able to reach as many teachers as possible with high degrees of efficacy. From their perspective, one conclusion is that both the sustainable delivery of valuable oTPD programs and the conduct of rigorous research used to demonstrate program efficacy must take equal priority.

Similar calls for the specification of both the design and the evaluation of whether programs achieve their intended goals have also been made for oTPD programs as a specific type of PD. Although some structural differences exist between face-to-face and online PD, Fishman and colleagues (2013) suggest that it is important to continually investigate the unique interactions that are afforded specifically by online approaches to better understand how they are useful toward meeting the goals of PD interventions. In comparison to their face-to-face counterparts, evaluations of oTPD programs should likewise address the methodological and structural research concerns raised by the scholarly community.

In the following sections, I elaborate on three general focal areas of PD and oTPD program and research design that have been proposed by the scholarly community to advance the field's knowledge about effective PD approaches, technologies, and learning processes.

2.2.1 Focal Area 1: Accounting for the Structure of oTPD designs

2.2.1.1 Specification of Goals and Intended Content of PD

Teacher PD interventions are intentional and systematic in their design. In other words, they are designed with a purpose to help teachers grow in some way. An underlying assumption with any PD is that the desired goals or educational outcomes of PD interventions determine the choices made by researchers and instructional designers in the content and ways in which teachers will participate (Dede et al., 2009; Guskey, 2000). A reasonable first step in any PD program design and its research is the specification of goals or desired outcomes and the content that will be encountered.

Historically, the goals of PD have been commonly discussed at two levels in the literature: within both student and teacher outcomes. Teachers are the primary implementers of such initiatives with their students. For any curricular initiative to realize goals of student achievement, the initiative needs to be implemented by teachers in the ways intended by researchers and instructional designers (Darling-Hammond & Bransford, 2007; Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). The ultimate outcome of any PD program then is to support student achievement, as this is the goal of teachers' in their practice (Guskey, 2000;

Marzano, 2003). Student achievement remains at least an indirect goal in PD interventions, even if the interventions are not intended to directly influence students. Indeed, in the rare occasions that it has been measured, student achievement is often conceptualized as a distal outcome from teacher PD (Cochrane-Smith & Zeichner, 2005; Desimone, Porter, Garet, Yoon, & Birman, 2002; Garet et al., 2010). To this end, the research efforts associated with PD programs should be designed to measure and support student achievement to some degree (Desimone, 2009; Fishman et al., 2013).

Teacher implementation of curricular reforms should be supported with robust training and ongoing support (Barab & Luehmann, 2003; Cohen, Raudenbush, & Ball, 2003). A second and more direct goal of PD initiatives is to affect changes in teacher disciplinary knowledge and beliefs associated with in implementing new pedagogies, curriculum, and standards (Fishman, Marx, Best, & Tal, 2003; Hammerness et al., 2005; Ehman, Bonk, & Yamagata-Lynch, 2005). PD should promote beneficial practices as well, such as the development of knowledge, skills, and beliefs that can support teachers' implementation of new curricula and pedagogies (Dede et al, 2009; Kennedy, 2016). Of particular importance in the PD literature is a focus on the implementation of curriculum initiatives in the ways intended by researchers and designers, also known as fidelity of implementation (FOI) of curriculum (Century, Rudnick, & Freeman, 2010; O'Donnell, 2008). To promote a high degree of FOI, PD goals and content should be aligned to the participating teachers' enactment of curricula in their classrooms, with PD activities working to communicate to teachers the procedures and purposes of pedagogy to realize expected benefits and achievement based on underlying theoretical assumptions (Harn, Parisi, & Stoolmiller, 2013; Gagné, Briggs, & Wager, 1992).

To meet these goals, designers of curricula and standards assume some responsibility for communicating the intent and processes of curricular interventions to teachers and empowering teachers to enact interventions over time. Designers should additionally expect that teachers need to be substantially supported to enact these novel approaches with a high degree of fidelity (Barab & Luehmann, 2003; Fishman et al., 2003; Penuel et al., 2007). From one perspective, Ertmer and Simons (2007) describe a number of critical factors that are related to supporting teachers who are new to student-centered pedagogies, such as having PD programs that allow the persistent ability to work with experts, share ideas, and find and critique examples of authentic classroom occurrences with teaching peers. Oliver and Stallings (2014) also argued that teachers additionally need to be supported to use new technologies, such as through offering technology training content in PD programs to support teachers who are new to blended learning environments and online learning technologies. In addition to describing implementation procedures, program content and goals should also promote teachers' understanding of the underlying rationale and learning theory of initiatives. Teachers will adapt curricular initiatives based on both their current levels of understanding and to meet their local classroom needs. However, being either too rigid or too flexible with established enactment procedures can lead to practices that might meet the nominal expectations of implementation, but can lead teachers to miss key implementation criteria (Brown & Campione, 1996; Cohen, 1990).

Fishman and colleagues (2013) agree that the primary way that PD can have measurable impact is to support teachers as they build knowledge, capacity, and skills toward curriculum and pedagogical implementation. To this end, they argue that the primary way to study the efficacy of PD interventions is to evaluate programs in the context of programs' specified goals in both the contexts of teacher and student achievement. They further argue that this must be done because the specification of goals and content allows researchers to establish comparison points between programs, as not all goals and internal content are equal among PD programs reported in the literature. Programs need to align its designed features and activities with the goals, content, and disciplinary knowledge that programs seek to provide teachers (Hammerness et al., 2006). However, a single feature or activity that is used for different goals may not necessarily produce the same results (Duffy et al., 2006; Gagné, Briggs, & Wager, 1992). Therefore, the efficacy of programs with varied content and goals are not fully comparable without the specification of a program's goals in a research report. Achieving such alignment is particularly challenging with oTPD, as online programs reported in the literature exhibit little consistency among the design features that are employed (Antoniou & Kyrakides, 2013; Rice & Dawley, 2009). Evaluations of PD programs would benefit from specifying and comparing goals, as well as the design features intended to achieve them.

2.2.1.2 Specifying PD Program Design Features: Toward Testing the Underlying Theoretical Processes of Professional Learning

Scholars have increasingly claimed that a consensus among the research community has been reached regarding the general theories and processes of professional learning that influence how professionals build their knowledge and practice in their workplace (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Rice & Dawley, 2009). As a result, similar arguments have been made that a consensus has been reached by the field on which theory-based learning features should be universally implemented in PD design to promote positive learning processes from PD programs (Desimone, 2009; Hawley & Valli, 1999). Each feature or activity employed in an oTPD program is designed based on underlying theoretical principles and is expected to contribute to a teacher's professional learning goals when teachers interact with it. Toward this goal, design features and activities employed in oTPD programs embody the theoretical commitments held by researchers and designers of these programs and provide testable examples of theory in action (Hochberg & Desimone, 2010; Wayne et al., 2008). Subsequently, the structural elements of oTPD should be investigated in formal research, as interaction with each feature can provide evidence toward the validity and effectiveness of the theories held by the research community toward achieving desired goals.

This consensus on general design features that are deemed essential within the research community has received much attention in highly cited position papers and design framework reviews in recent years (Jeanpierre, Oberhauser, & Freeman, 2007; National Staff Development Council, 2001; National Research Council, 2007). Although scholars have often suggested lists of the important elements that lead to successful PD, the research community does not recognize a single "consensus" document or list in the field's literature that contains an inventory of the popular PD design features or best practices. Despite the lack of a single document, the authors of studies that discuss a "PD consensus" frequently argue for features that are built upon similar theory-based processes for professional learning. The repetition of arguments for certain design features across multiple studies reveals that these design features in the consensus literature can be categorized based on the common theoretical commitments embedded in features. A consolidated review of the common features that are implemented in PD is highly useful to the field as it allows researchers to continually identify similar innovations in the field, which may differ in their implementation or with the technologies utilized. In addition, reviews of design features can provide a current "road map" of popular features and best practices and highlight features that have promise for providing transformative learning experiences. Table I provides a summary of each of common design feature groups that have been cited as necessary in the PD literature. In addition, each of these feature groups is discussed in the paragraphs that follow.

For the first category, many scholars agree that PD programs should employ *active learning* approaches, or that the participant should be actively engaged with PD activities and not just passively receive information (Antoniou & Kyrikides, 2013; Desimone, 2009; Timperley & Alton-Lee, 2008; Wilson & Berne, 1999). This principle closely aligns with broadly accepted theories of constructivism and related paradigms, in which learning is a process by which the learner builds new understandings from prior knowledge and new experiences (Webster-Wright, 2009). To this end, Duffy and colleagues (2006) suggest that professional learning is more about teachers doing activities, instead of having activities *done to them*, such as through passive activities like watching lectures or sitting through workshops. Instead, teachers need to effortfully engage with activities for the activity to have greater impact. Active components are intended to allow participants to connect PD concepts with their daily non-PD activities. With different terminology toward this commitment, Wilson and Berne (1999) argue that PD shouldn't be viewed as something to be *delivered* on part of the provider, but instead *activated* through participation and the subsequent use in practice by the teacher. Kazemi and Hubbard (2008) agree with this idea, suggesting that for teachers to genuinely learn from PD, they need a chance to actively connect new concepts, ideas, and insights during the PD by the subsequent use of concepts and skills in practice. As an option toward meeting this goal, PD programs that leverage active learning principles frequently employ activities that promote participants to be creators of artifacts, content, and discussion rather than be mere consumers of such.

TABLE I

COMMONLY CITED CATEGORIES OF THEORY-BASED PD DESIGN FEATURES

Theory-Based PD Design Feature	**Description and Processes**
1. Active learning	Program activities should consist of teachers' active engagement, as opposed to passively receiving information.
2. Authentic learning, applied in classroom contexts	Activities are embedded in teachers' everyday work, tasks can be directly used in classroom and school contexts. Teachers bring their everyday work, knowledge, beliefs, and prior experiences to learning opportunities, which will influence how they make sense of information and interact.
3. Social learning through social interactions	Participants interact with other people, particularly other professionals or experts in the field. Interaction with others that are at the same level as the participant, as well as those more experienced than the participant. Social interactions help participants collectively make sense of phenomena and information.
4. Reflection, introspection, self-awareness in relation to practice	Insights are gained by reflecting on and evaluating prior experiences. Reflection can reveal new connections, things to try in practice, and opportunities for improvement. Shifts can occur in a teacher's knowledge, skills, beliefs, interests, goals, and identities as they evaluate their experiences.
5. Ample, varied, and usable resources and supports	Multiple on-demand resources and media are available to help teachers better understand content and provide support to teachers when needed. Media choices help communicate meaning in different ways. Teachers learn well both structural supports and cognitive tools to achieve PD objectives.

Similarly, PD design scholars frequently cite the necessity for a second category of design features that foster *authenticity* in PD learning activities. This approach is particularly important for professionals, as it avoids giving teachers experiences that they cannot directly use in their everyday work (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Hawley & Valli, 1999; Kazemi & Hubbard, 2008). It is equally important for PD designers to account for and provide coherent alignment of PD activities with the practices that teachers already perform in order to expect any positive change to occur (Anderson & Herr, 2011; Ball &

Cohen, 1999; Hochberg & Desimone, 2010). To accomplish this, Ehman and colleagues (2005) suggest that a good example of authentic PD is to have teachers generate classroom tools during PD, such as lesson plans, worksheets, or data collection tools, that can be implemented in classroom practice immediately and are tailored to teachers' specific needs. To this end, they further suggest that PD should also adapt to teachers' ongoing needs and, if possible, base the activities on teachers' school-based, local classroom contexts.

One way that program designers have suggested that the level of authenticity of PD programs can be increased is by recruiting teachers to cooperatively design PD programs alongside instructional designers and researchers (American Federation of Teachers, 2008; Desimone, 2009). Such direct involvement by teachers in the development process ensures that teachers are examining topics that matter to their everyday practice and recognizes the expertise of teachers in how their classrooms really operate (Ehman, Bonk, & Yamagata-Lynch, 2005; Shulman & Shulman, 2004; Timperley & Alton-Lee, 2008). In addition, Hawley and Valli (1999) argue that collective participation in the design of PD programs can additionally increase motivation and commitment of teacher participants as they study issues of importance to them at the time of the PD. Similar to teacher involvement with planning PD, The American Federation of Teachers (2008) argues that it is essential to additionally connect PD activities to the educational standards used by schools. A standards-based approach to PD would thus provide teachers opportunities to consider applications of PD content to the policy contexts in which they work.

In a third area of PD design, scholars have emphasized the importance of promoting *social interactions* in PD programs. Professional learning is not an isolated activity, but instead embedded in the multi-layered practices, experiences, and knowledge of teachers in their classrooms, local school communities, school districts, and the teaching profession as a whole (Hammerness et al., 2005; Putnam & Borko, 2000; Shulman & Shulman, 2004). This emphasis on social interaction originates from the body of research over the last three decades on professional communities of practice and how professionals learn in their everyday work contexts (Barab, Kling, & Gray, 2004; Lave & Wenger, 1997; Wenger, 1998). This feature additionally draws on broader sociocultural perspectives of learning, which posit that learning is a fundamentally social process. Learners continually build knowledge and understanding through dialogue among participants, or through continual negotiation of meaning (Duffy et al., 2006). People tend to learn well through regular practice in performing social activities as peers provide feedback and opportunities to continually refine one's understanding in a group setting, as understanding and meaning making are largely socially-mediated practices (Rogoff, 2003; Vygotsky, 1978). Therefore, opportunities to interact with other professionals and experts is essential for not only understanding new content and practices that are the focus of PD programs, but understanding how the content is contextualized in the authentic practices and challenges that professionals experience.

The social emphasis design feature has been frequently implemented in PD programs through systems that promote coaching and mentoring between novices and experts (Duffy et al., 2006), the purposeful analysis of others' insights and work and the integration of such into participants' own practice (Ehman, Bonk, & Yamagata-Lynch, 2005; Putnam & Borko, 2000), or the provision of spaces for online collaboration and community development to allow teachers to collaborate on real problems and challenges, as well as to build relationships with other participants (Barab, Kling, & Gray, 2004; Darling Hammond et al., 2009; Hammerness et al., 2005; Hawley & Valli, 1999).

Fourth, scholars have frequently cited the *need for professional learners to reflect* on both the formal learning experiences they have in PD programs, as well as their everyday practice (Duffy et al., 2006; Schön, 1983). For instance, Ehman, Bonk, and Yamaguta-Lynch (2009) suggest that PD programs should systematically promote the reflective analysis of work in PD programs in connection to authentic classroom teaching help teachers gain insights and self-awareness of practice. Similarly, Hammerness and colleagues (2009) argue that reflection and similar introspective meta-cognitive activities are an essential part of the learning process that allow teachers to place lessons learned in PD into the contexts of their students and schools needs. Again, per Hammerness and her colleagues, reflective activities align well with what is known about student-centered learning processes in which learners, through taking time to analyze past experiences and generate new insights, can transfer experiences from one context to another (Bransford, Brown, & Cocking, 2000).

Reflective activity should not be "busy work," but instead a constructive, valuable activity that has the potential to provide insights not elsewhere gained. This allows for learners to critically analyze past experiences to infer new knowledge and adapt practice accordingly. Scholars have noted that this type of activity does not always come naturally to professionals, so it should be scaffolded and modeled (Gikandi, 2013; Hoban & Hastings, 2006). Activities that engage participants with their experiences and encourage them to examine their experiences from multiple perspectives have the potential for insights that cannot be simply delivered in a PD (Hammerness et al., 2005). Indeed, the commitment to reflective activities in PD is additionally echoed by other scholars who have found the need to create structured opportunities for reflection, which subsequently allows teachers opportunities to make actionable conclusions about their PD experiences (Shulman & Shulman, 2004; Webster-Wright, 2009).

Finally, a fifth common design feature in the PD literature emphasizes *ample and varied activities and resources* available to teachers in PD programs to increase the potential for creating a personalized learning experience (Antoniou & Kyrakides, 2013; Hochberg & Desimone, 2010). For instance, Duffy et al. (2009) suggest that PD programs should offer teachers opportunities to access and integrate a diverse array of information, worked examples, and artifacts from other teachers to integrate into their own work based on their personal needs. Similarly, they argue that PD activities that can be tailored to address the specific challenges that a teacher experiences in their classroom. In addition to offering ample information and activities for teachers based on their interests and needs, information should be represented by multiple types of media and always available for teachers to access when they have a need (Fishman, Marx, Best, & Tal, 2003). Information-rich resource offerings in PD programs allow for the use and evaluation of multiple sources of information that can communicate meaning in different ways based on teachers' individual preferences (Hawley & Valli, 1999). Because they can be accessed at any time via the web, oTPD programs are well-poised to offer access to such a resource library or repository to teachers when they need it (American Federation of Teachers, 2008; National Research Council, 2007). To support meeting teachers' specific interests in PD, Antoniou & Kyrikades (2013) additionally argue that a dedicated expert coordination team is useful for helping teachers connect PD informational resources with their interests and for guiding participants toward productive outcomes. The personalized access of informational resources and dedicated support is particularly important as PD programs are scaled up to meet the needs of larger numbers of participants.

The need for feature-level analysis of interventions. Despite the general agreement in the literature on the ideal principles for conducting PD, some challenges to the design-feature consensus have been persistently been raised by scholars. Regularly cited as the chief of these concerns are that the links between the features and theories employed to enact change, teachers' use of features in PD, and teacher and student outcome efficacy have not been extensively investigated in empirical PD contexts (Fishman et al., 2003; Hill, Beisiegel, & Jacob, 2013). In an important critique of the field's experimental findings to date, Wayne and colleagues (2008) suggested that the overall body of evidence that has currently been presented on PD efficacy is substantially weak to support claims that popular PD features and the theoretical principles upon which features are constructed *actually work* as intended. They further argued that when PD intervention efficacy is in fact investigated, it is often examined at the whole-program level without regard to the individual features that compose a program. Design principles and features in PD reflect and are inextricably tied to the theories and assumptions about teacher professional learning that are held by designers. In their argument, they remind the research community that the PD features chosen by designers to promote interactivity and individual actions in programs embody the theoretical commitments and expectations of designers. Therefore, PD studies should specify and test the theoretical assumptions by investigating teacher interactions with the individual features of the PD toward achieving program goals.

Similarly, Hochberg and Desimone (2010) have recently issued a challenge to the PD community toward better specification and empirical testing of individual features in PD programs toward providing evidence of the efficacy of PD interventions. Their argument stems from the traditional approach of investigating PD programs as whole packages with single treatment variables, or, alternatively, as "black boxes" within which the inner functions and interactions are not accounted for in studies. They argue that it is no longer sufficient to examine PD interventions as whole, packaged PD programs, as these types of studies would reveal little about the specific processes and expected outcomes as a function of each feature within the PD. This point echoes the similar argument by Wayne et al. (2008) that suggests each feature should be specified and tested in order to continually validate within the literature the theoretical assumptions upon which PD features are built. When adopting this argument, evaluations of PD need to specify and examine the individual design features of PD toward meeting the goal of knowing whether PD interventions work. Additionally, although research methods might differ within the PD literature, Webster-Wright (2009) emphasizes the importance of regularly testing the assumptions and theories about teacher learning in order to build up the literature base and the field's knowledge on efficacious PD program design and to refine theory on teacher learning. This can be accomplished in part through rigorous investigation of the effects of both whole programs and individual interactive features in PD within peer-reviewed studies.

Developing an implementation consensus for oTPD. Additionally, although the design consensus on the features and theoretical principles is widely held in the PD community, the field is currently lacking a consensus on how these features should actually designed or implemented in PD programs, such as making decisions on which technologies to use or how participants should specifically interact. To this point, Rice and Dawley (2009) observe that although there is indeed an array of choices regarding PD features and models for designers on which details have been extensively published, designers often struggle with practical questions on how to make a program or decide on features. Indeed, PD programs have shown substantial variation in technologies, software, activities, patterns for interaction, and theoretical models (Fishman et al., 2013). To complicate matters further, studies often lack the depth of design reporting that is needed to promote replicability and comparison across design features (Wayne et al., 2008). As a result, there has been reported in the literature an abundance of boutique PD programs with uniquely designed features, but scant sharing and adaptation of practical design knowledge and little evidence of design feature efficacy. Evaluations of oTPD should then document the theories and principles by which designers expect to meet the PD goals and details on the specific features that were implemented, as well as the links between features and theoretical principles.

These are challenges toward improving the value and validity of the design consensus that the field has worked hard to achieve. Future evaluations of oTPD should provide rigorous evidence toward the effects and processes related to design features to help both designers and researchers make informed decisions about what features to implement and how to implement them in effective ways. Because oTPD is frequently informed by traditional PD models, it is worth examining both PD and oTPD studies toward taking an inventory of the interactive features of oTPD (Dede et al., 2009). An evaluatory review of oTPD research on the features reported in the literature can provide an important inventory of advances in the field, such as documenting the relative popularity of certain features, identifying new features and technological advances, and tracking changes in how design principles and theories are implemented as a result of continued PD practice.

2.2.1.3 Specifying the Duration of PD

The literature has also frequently attended to the duration of PD interventions. Although duration could be seen as a design feature that could be included in the discussion in the previous section, it is unique among features as it can be highly varied in its own right and has been examined in multiple ways. The *duration,* or amount of time spent participating in a designed oTPD, is treated in this study as its own sub-dimension for investigation.

PD interventions have historically exhibited substantial variation in program duration. Traditionally, PD programs were offered at one single time characterized the so-called "one-shot" workshops (Parsad, Lewis, & Farris, 2001). In a direct challenge to programs that last only for a short duration, scholars have argued that PD designers should plan for an extended duration for desired outcomes to take effect (Akerson, Morrison, & Roth McDuffie, 2006; American Federation of Teachers, 2008; Darling-Hammond et al., 2009). Other scholars have argued that longer-term and ongoing PD should provide teachers ample time to integrate, experiment with, and adapt the content from PD in their classrooms, which doesn't necessarily equate with a long duration, but must be enough time to substantially influence teacher practice (Hawley & Valli, 1999; Kazemi & Hubbard, 2008). For example, Stanford-Bowers (2008) argues that online learning programs can provide flexibility for working professionals, allowing participants to interact when they are able to during a busy everyday schedule or when they perceive a need, thereby adding to the authenticity of the learning opportunity. However, programs do not have to be of infinite duration. Scholars have argued that PD programs should instead should be of a sufficient sustained duration to meet goals and integrate into participants' long-term, authentic practices (Desimone, 2009; Hochberg & Desimone, 2010).

As reported in previous reviews, traditional one-shot PD programs typically lasted for as little as an hour to 1-3 days (Goodall, Day, Lindsay, Muijs, & Harris, 2005). However, as scholars have increasingly adopted a long-term view of PD, PD interventions have likewise varied in duration to meet the ongoing needs of teachers, including programs that have been as long as a year or more (Akerson, Morrison, & McDuffie, 2006). In addition, some types of programs operate completely without time constraints or bounded start-stop times entirely, such as with online communities (Booth & Kellogg, 2015; Barab, Kling, & Gray, 2004; Macià &

García, 2016) and ongoing, just-in-time programs for teachers to provide information to teachers when they need it (Anderson, Wood, Piquette-Tomei, Savage, & Mueller, 2011; Riel, Lawless, & Brown, 2017; Tour, 2017). To this end, the duration and other timing aspects of PD should be regularly evaluated in the field as an aspect of program structural design, as variation in PD program duration has been demonstrated to be a significant factor related to quality of participant experience and outcome achievement (Penuel et al., 2007).

2.2.2 Focal area 2: Essential Research Designs for oTPD

2.2.2.1 Accounting for Experience with and Participation in Individual oTPD Design Features

Those who use modern online, interactive technologies often have non-uniform experiences as a result of affordances of personalization, time flexibility, open communications, and user-generated content. In their review of experimental methods for use in PD research, Wayne and colleagues (2008) suggest that if researchers view PD as a complete, whole package (or, more colloquially, as a "*black box*"), researchers cannot account for differences in experience that are afforded by modern technologies. This is important to capture in modern, rigorous studies, as different functions and features within an online PD may mediate different experiences and learning outcomes for participants. Also, as oTPD interventions are often a complex mix of design features implemented with multiple technologies, it is reasonable to expect that participants could interact in PD interventions to varying degrees, with each using a different combination of features. According to Wayne et al. (2008), a lack of accounting for variations in experience with or exposure to various PD features is problematic when investigating program effectiveness because it obscures the links between how much the intervention was used by participants and the measured outcomes. To illustrate their point, Wayne et al. compare the measurement of the *experience with* or *exposure to* a PD intervention to being similar to the value of measuring *dosage* in clinical medical drug trials. In this argument, they state that PD studies should measure the participants' exposure to the program's features to identify the degree to which the intervention had any role in the learning process. As a result, measuring experience allows researchers to know the *degree* to which an intervention or treatment was used within a study.

From a general online learning perspective, Hrastinksi (2009) echoes the necessity for accounting for experience or exposure to features of online learning interventions. In his review of online participation concepts, Hrastinski argued that participation in online courses is indeed the act of learning itself: it is through various interactions with the online system, information, activities, features, and communications tools that learning occurs. Measuring the experience and participation within different features of online learning environments gives measures of the process of learning. To this point, he argued that to best know how online learning environments work to promote growth in participants, the field needs to understand both the amount and various types of interactions that occur within the various features of a designed environment. This would ideally involve mixed-methods analyses of both the quantity and qualities of participation in these environments.

Historically, PD studies have not been completely absent of measures that account for variation in participation within PD. Because it is the act of participation that reveals how PDs are used and to what ends, any study that investigates and describes the processes of learning within PD invariably involves the capture and analysis of data on the qualities of the experiences of teachers in PD (Dede et al., 2009). Such studies also often seek to identify and describe different types or categories of interactions that learners perform in PD, which is valuable to the research community as measures are reported and validated (Greene, Oswald, & Pomerantz, 2015; Kovanović, Gašević, Dawson, Joksimović, Baker, & Hatala, 2015; Oliver & Stallings, 2014; Perna, Ruby, Boruch, Wang, Scull, Ahmad, & Evans, 2014). From the perspective of PD efficacy, the research community has sometimes used “counts” of participation to examine the amount of interaction within an intervention. In typical studies, this has included counting the number of clicks, website pageviews, forum or message board posts, and length or word count of participant writing tasks (DeBoer et al., 2014; Kovanovic et al., 2015; Miyamoto, Coleman, Williams, Whitehill, Nesterko, & Reich, 2015). Alternatively, the duration that a teacher has participated in PD has also been used (Garet et al., 2001; Riel, Lawless, & Brown, 2016; Penuel et al., 2007).

With today’s online media and its potential for collecting unobtrusive interaction data, more opportunities are presented to researchers for understanding differences in experience. For example, DeBoer and colleagues (2014) recently examined the myriad possibilities that are possible from server log data in massive online courses. They reveal that many variables easily obtained from unobtrusively collected interaction or clickstream logs can reveal information about different levels and characteristics of a participant’s use of an online system. Possibilities include a great number of ways to measure the online “presence” of a participant, the timing of participant actions, the use of written communication or creative works, and the ability to track participants along curricular sequences and paths. From a teacher PD perspective, the author of the present review and his colleagues have also recently developed variables that investigate variation in levels of participation in oTPD and associated effects using web server logs from oTPD environments (Riel, Lawless, & Brown, 2016; 2018). To this end, the literature demonstrates many different ways that experience and exposure to PD interventions could be measured, which signals the possibility of substantial variation in how participants might interact in an online PD environment. However, despite the historic presence of measures of experience and exposure in the PD field, the use of these types of measures in oTPD studies has been sporadic, with most studies opting to examine PD experience variations in simple binary terms of treatment and control assignment (Wayne et al., 2008).

Kreijins, Kirschner, & Joschems (2003) have reminded the research community that just because technologies and design features afford certain desired actions for participants, it does not mean that these desired behaviors will necessarily occur. They further argue that multiple factors and conditions are likely required in order to engage participants to perform expected behaviors, such as goal expectations, perceived value and purpose of PD activities, usability of technologies and features, design, teacher motivation, and teacher perceptions. As such, it cannot be assumed that oTPD programs and their individual features will work according to expectation and design just because they are present. Similarly, Motteram (2006) reminds researchers that it is not entirely possible to capture all of the work or interactions that teachers perform in oTPD interventions, particularly those that occur offline in support of online activity. However, despite this limitation, many interactions are required to be performed online, and can be recorded using unobtrusive capture methods, such as server or clickstream logs as participants interact with the intervention. To this end, measuring how and the degree to which PD features are used is essential to understanding their effects on learning.

Modern data collection technologies as part of websites and digital applications provide a prime opportunity for the evaluation of oTPD to account for the different types and effects of the participation patterns, types of experience, and levels of exposure with the interactive features within a PD intervention (Dawson, 2006; Dede et al., 2009). The evaluation of experience and exposure should also be a fine enough grain size to examine participation not at the whole program level, with a special focus on analyses that capture data at the *feature* level to identify what elements of PD designs work as expected (Hochberg & Desimone, 2010; Wayne et al., 2008). Thus, the sentiment from the research community again reflects the importance for researchers to specify the individual features that compose oTPD programs to aid in the evaluation of PD efficacy. In addition to its research value, participant exposure and experience provides practical usability data that can inform future oTPD development.

2.2.2.2 Productive Research Foci to Inform Future Design and Investment

oTPD studies have historically asked research questions aimed at both the advancement of theory and the improvement of programs. Although the goals of any oTPD programs is program efficacy, research studies do not always investigate the degree to which programs had an effect on participants or students (Desimone, 2009; Fishman et al., 2003; Lawless & Pellegrino, 2007; Penuel et al., 2007). In addition to efficacy studies, other common themes of research questions or foci have been observed in recent years that investigate multiple aspects of program design and interaction. In their review of oTPD before 2008, Dede and colleagues (2009) observed four research foci that were common to the literature: (1) program design reports, (2) program effectiveness, (3) program technical design, and (4) studies on learner interactions. Similarly compatible to the list of foci by Dede et al. are the categories forwarded by Lawless and Pellegrino (2007) that can be used to sort technology-based PD studies based on their research questions and design. These categories include (1) program descriptive reports or evaluations, (2) qualitative case studies that are designed to investigate details of learner processes and interactions, and (3) experimental approaches designed to investigate questions of efficacy. The varied approaches to PD investigation highlighted in these reviews illustrate the value of investigating oTPD interventions across multiple lines of inquiry. The two above-mentioned literature reviews highlight four common research foci. These four categories are drawn from the categories of research foci by Dede et al. (2009), which are further examined and expanded upon below based on issues raised by members of the research community.

First, many PD studies have been observed over the years that focus on providing *design reports and program descriptions*. Dede et al. (2009) describe this category of studies as containing rich descriptions of programs and informally measured evaluations of program attainment of anticipated goals. Also included in this category, and echoed in the review by Lawless and Pellegrino (2007), are evaluations that gauge the satisfaction of participants as to the perceived value, interest, or applicability of course experiences. However, although satisfaction studies provide valuable indicators of the participant's experiences, such self-report measures do not provide observable accounts of teacher behavior, skill, or application of knowledge gained as a result of the PD. Additionally, a research focus on design or descriptive evaluation does little to provide empirical evidence on the efficacy and underlying theory of PD programs (Wayne et al., 2008). Although studies with this focus often richly describe the programs under study and offer anecdotal evidence about the value and satisfaction of programs might be provided, such reports often do not follow the rigorous evidence standards for efficacy set by the community and fails to answer "what works and why" in a robust way.

As a response to the need for rigorous evidence, a second group of research studies focus on *program effectiveness*. Dede et al. (2009) describe that research on efficacy typically compares one group of participants in a PD program with a group that either does not participate in the program or participates in an alternate PD program that is not the focus of the study. However, additional scholars contest that the literature exhibits a dearth of research that focuses on “what works” (Borko, 2004; Dede et al., 2009; Lawless & Pellegrino, 2007; Wayne et al., 2008)). When performed, program effectiveness research has often followed a conventional experimental “treatment and control” approach to provide measurable comparisons between participant groups on various outcome measures (Desimone, 2009; Fishman et al., 2003; Garet et al., 2001; Penuel et al., 2007). Additionally, programs often compare a single group of PD participants over multiple time points to see if the program had any effect, which can be described as “observational-type” efficacy studies that do not use a randomized control condition (Shadish, Cook, & Campbell, 2002; Wayne et al., 2008). Although observational studies do not necessarily compare two groups of participants, nor are participants randomized, these approaches are useful for providing “proof of concept” toward identifying what works in PD (Hochberg & Desimone, 2010; Wayne et al., 2008). However, true randomized experimental studies are often difficult to implement, can be costly, and often are not feasible based on the goals or intent of the PD (Desimone, 2009).

It is perhaps most important to the field that PD program efficacy be investigated to provide researchers, designers, and policymakers with information on how goals can be best achieved and how to allocate investments in PD (Wayne et al., 2008). In addition, basic PD research is rarely funded or conducted, with most of the field’s research being conducted in a secondary nature on pre-existing PD programs or programs that were designed to support curricular research initiatives that are the primary focus of research agenda and designs (Hochberg & Desimone, 2010; Marrongelle, Sztajn, & Smith, 2013). Despite these challenges, multiple reviews of the process and agenda of PD research have cited the increased need for evaluating the efficacy of programs when possible and following best practices for rigorous research when possible (Borko, 2004; Dede et al., 2009; Desimone, 2009; Lawless & Pellegrino, 2007).

Third, a program's *technical design* might be investigated. Dede et al. (2009) describe research on program technical design as a focus specifically on one element or technology of a PD to better understand how it works in combination with the PD and how participants interact with it. From this perspective, in their classification in this category, the focus is on evaluating the individual technology or design feature, and not necessarily on the participant or the program as a whole. This focus is helpful for informing future iterations of the technology design, but again does not necessarily address larger questions about overall program efficacy or investigate how participants function within PD interventions with the intent of advancing theory on professional learning.

Fourth, participant *interactions and processes* within a PD program have been examined by researchers to better understand the contexts and processes by which participants learn in a PD program. According to Dede et al. (2009), these types of studies frequently exhibit rich descriptive accounts of how learners progress in PD, follow sequences or patterns of interaction, and exhibit changes throughout the learning experience. In addition, variables that represent learning interactions can also be quantitatively measured and tested through efficacy trials if the theoretical processes are clearly specified (Borko, 2004; Desimone, 2009; Wayne et al., 2008). The examination of process and interaction in learning is a valuable approach for theory generation and refinement, but by design have historically not examined the efficacy of programs (Dede et al., 2009; Hochberg & Desimone, 2010; Lawless & Pellegrino, 2007; Marrongelle, Sztajn, & Smith, 2013).

2.2.2.3 Toward Promoting Salient Research Questions and Rigorous Methods

To answer the questions associated with the research foci examined in the section above, scholars have implemented a variety of methods to collect and analyze data associated with PD programs. In their review of technology-based PD programs, Lawless and Pellegrino (2007) observed the use of multiple research methods, many of which mirror that of general social science research. From their review, program evaluations and surveys that gauge participant satisfaction and perceptions are some of the most common methods employed in PD research. Although they are empirical, they do not typically respond to whether outcomes were observed, nor if outcomes were achieved as a result of participation in the PD program. Descriptive case studies are also often used by scholars that seek to answer questions about the processes of learning and interactions by participants. Similar to case studies, rich descriptive design reports that carefully explain design decisions and technical specifications are also a frequently observed method in PD studies, as scholars often implement actual PD programs with the primary intent of promoting participant learning and not necessarily basic laboratory research. Although they contain much practical design information and are essential to the field, design reports often do not rigorously investigate research questions associated with PD and are subsequentially inadequate to respond to questions as to what works and why with PD (Lawless & Pellegrino, 2007).

Of particular importance concerning the methods observed in their review, Lawless and Pellegrino (2007) highlight methods that allow for quantitative comparison of groups to determine the efficacy of PD interventions. The three types of comparison methods include pure randomized experimental field trials, quasi-experiments, and single-group observational studies. However, despite being cited as important to the field, efficacy studies in general have represented only a small portion of studies as observed in previous reviews of the literature (Dede et al., 2009; Desimone, 2009; Garet et al., 2001; Lawless & Pellegrino, 2007). Experiments in which the participants are randomly assigned to multiple groups are the most desirable for providing rigorous evidence of efficacy as they eliminate selection bias and improve internal consistency of the experiment (Hochberg & Desimone, 2010; Wayne et al., 2008). Truly randomized field trials have been historically difficult to implement with PD interventions because of the “real-life” implementation of PD interventions in which research is often secondary to the intervention, as well as the fact that PD interventions to date have largely been composed of voluntary, self-selected participants (Desimone, 2009; Wayne et al., 2008). To this end, some of these structural challenges might be impossible to overcome in PD. Wayne and colleagues (2008) have responded to this issue by stating that the difficulties with completely randomized field trials in PD studies can be mitigated through careful design in both quasi-experimental and single-group observational designs, such as through participant group weighing and sorting by participant demographic. Careful efforts to increase internal validity would allow for high-quality efficacy studies to be conducted, even when experimental conditions are not at their most ideal.

For oTPD interventions specifically, Dede and colleagues (2009) have challenged scholars to respond to the field’s emerging research agenda by using methods for data collection and analysis that meet specific affordances and needs associated with oTPD programs. First, they suggest that oTPD researchers should increasingly leverage design-based research (DBR) or design experimental approaches (Brown, 1992; Barab & Squire, 2004). DBR approaches work well in contexts that involve the collaborative design of learning environments and the prioritize the iterative testing of technologies and activities as they are used in authentic learning contexts (Wang & Hannafin, 2005). Researchers, designers, and participants can engage in continual cycles of inquiry to investigate how and why interventions are working and how participants engage with them. DBR-type studies typically result in rich descriptions of interventions that are useful for subsequent designs and transfer to other PD contexts (Barab & Squire, 2004; Dede et al., 2009). As a result of the rich descriptions of interactions that appear in the literature, DBR approaches can also inform learning theory through the specification and description of learning processes and logic models, as well as identifying factors that might influence learning interactions (Brown, 1992; Wang & Hannafin, 2005).

Second, Dede and colleagues (2009) encourage scholars to take advantage of the rich data collection opportunities that online learning environments naturally afford. This includes the use of system-generated data, server logs, and user clickstream records to determine with precision what, when, and how participants use the various features of online environments. The emerging fields of learning analytics and educational data mining all exemplify the promise that the use of web analytics data sources can provide to educational research, including that for oTPD efficacy. For instance, because these types of data typically include timestamps, the influence of sequence, timing, and duration in learning environments can be examined in detail (DeBoer, Ho, Stump, & Breslow, 2014; Riel, Lawless, & Brown, 2016). Additionally, because these data can be both measured quantitatively and examined qualitatively, the opportunities for mixed-methods approaches to answering the research agenda are also promising.

2.2.3 Focal Area 3: Units of Analysis

A third focal area for evaluating oTPD programs is concerned with the units of analysis and variables of interest in studies. To this end, researchers have historically examined three types of units of analysis or categories of variables in the PD literature: program, teacher, and student (Lawless & Pellegrino, 2007). When concerning the goals of PD programs and the directions in which the oTPD research agenda has moved over the last two decades, these three categories are reasonable and can be used to answer necessary questions unique to each category.

First, program-level analyses are important for understanding the composition and value of programs to teachers and their schools. Program-level units of analysis are used to examine programs as a whole as the primary interest of a study. These studies have typically been composed of program evaluations, case studies, or satisfaction surveys from participants. However, multiple scholars have argued in recent years that studies that utilize program-level units of analysis should advance past conducting solely satisfaction studies, design reports, or descriptive program evaluations and additionally investigate questions of program efficacy that employ rigorous measures and standards for evidence (Dede et al., 2009; Wayne et al., 2008). Program-level variables, however, remain an important aspect of understanding how PD interventions work, especially when investigating the effects of PD programs at scale, or comparing the effects of multiple PD programs.

Second, as teachers are the primary recipients of PD programs, research studies frequently examine changes in teacher participants as units of analysis. Typical variables in this category include level of participation (Henrie et al., 2015; Hrastinski, 2009), teacher dialogue and communications during PD (Kazemi & Hubbard, 2008; Putnam & Borko, 2000), individual teacher written artifacts and other creative works (Gikandi, 2013; Hoban & Hastings, 2006), video analysis of teachers' practice (Borko, Jacobs Eiteljorg, & Pittman, 2008), and assessments and surveys that gauge teacher self-reported knowledge, attitudes, and behaviors (Borko, 2004; Desimone, 2009; Lawless & Pellegrino, 2007). Teacher-level units of analysis have been helpful for the examination of the processes of learning in which teachers engage in PD programs, as well as for determining whether desired changes occurred with participants as a result of the PD program (Desimone, 2009). Indeed, as has been discussed at length in the literature, analyses of change in teachers' knowledge, behavior, and beliefs should be prioritized as a part of the ongoing oTPD research agenda (Dede et al., 2009; Hochberg & Desimone, 2010; Marrongelle, Sztajn, & Smith, 2013; Lawless & Pellegrino, 2007). However, scholars have argued that teacher-level analyses should prioritize the investigation of *actually observed* behavioral changes in teachers during PD in contrast to *self-reported* changes in behavior. Such observations are especially important for objectively determining the efficacy of PD programs and whether they meet their goals (Koziol & Burns, 1986; Lam & Bengo, 2003). The continued inclusion and analysis of teacher-level variables, especially those that are directly observable, will be essential for the advancing the oTPD research agenda.

Third, as students are the ultimate, albeit indirect recipients of PD interventions, some studies have historically included student-level variables to account for changes in student achievement as a result of PD (Fishman et al., 2003; Garet et al., 2001; Lawless & Pellegrino, 2007; Penuel et al., 2007). In order to understand “what works and why” in PD, studies should increasingly analyze student-level data to investigate whether achievement occurs from novel curricula and standards initiatives, and the degree to which supportive PD interventions play a role in mediating achievement from such curricula or standards (Darling-Hammond et al., 2009; Hochberg & Desimone, 2010; Wayne et al., 2008). Studies need not exclusively examine the effects of PD interventions on student achievement or learning processes, but some effort should be made by the community to investigate student-level measures when appropriate to provide a continued source of evidence for the efficacy of PD programs (Fishman et al., 2003; Hill, Beisiegel, & Jacob, 2013; Wayne et al., 2008).

Each category of variables is essential to answer the full set of questions about PD efficacy. However, as the ultimate goal of PD is student achievement, multiple scholars have called for an increased focus on student-level analysis in PD studies (Fishman et al., 2003, Fishman et al., 2015; Lawless & Pellegrino, 2007). In addition, these three units of PD analysis can be simultaneously examined during PD evaluations to explore questions of program value and alignment to the field (Garet et al., 2001; Penuel et al., 2007; Wayne et al., 2008). Such investigations are essential for the continued development of the field’s understanding of whether the interventions being designed by the community actually work and to advance the theories upon which these programs are built (Hochberg & Desimone, 2010; Lawless & Pellegrino, 2007).

2.2.4 A Framework for Evaluating and Constructing oTPD Research

The three focal areas discussed in the sections above highlight issues that scholars have outlined as essential for both PD and, by extension, oTPD research in future years. To synthesize these criteria presented by the scholarly leaders of the field, I use an adapted version of the multi-dimensional evaluation framework as utilized in Lawless and Pellegrino (2007) for organizing the field's current thoughts and criteria specifically on oTPD research and program design as a subset of broad teacher professional development. In describing their PD evaluation framework, Lawless and Pellegrino state that such a framework "can be used retrospectively to classify programs and research studies and prospectively to define possible research and evaluation study designs" (p. 582). Such a framework allows for the systematic investigation of interventions in the field's peer-reviewed literature that can focus on and respond to the research agenda items laid out by the scholars in the field and accounts for unique aspects of conducting investigations of oTPD. In addition, the framework can be applied to future oTPD studies to emphasize the areas that should be both specified and investigated in published reports regarding the design of programs and research studies.

In a single oTPD study, the three focal areas might each be discussed and investigated based on the study's research questions. Toward this goal, it is entirely feasible that each of the three foci can be described in future studies enough detail by scholars to provide the necessary evidence for comparing programs, design features, and outcomes with sufficient rigor. This is particularly useful in today's digitally ubiquitous oTPD landscape where unique implementation and research challenges have been recently observed when using complex web-based technologies. Figure 1 provides a graphical representation of the three focal areas as a framework for oTPD evaluation and analysis of program effectiveness. When examined together, these three focal areas provide a comprehensive snapshot of individual PD programs and represent a guiding framework for evaluating the degree to which the research mandates that have been stressed by scholars in recent years have been addressed.

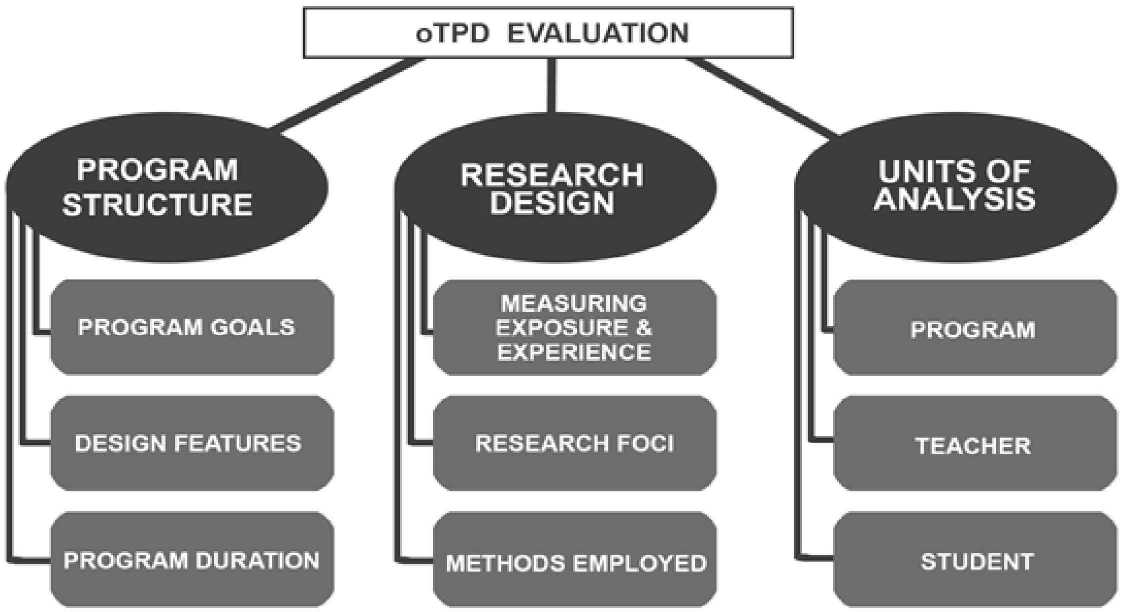


Figure 1. Three-foci oTPD evaluative framework (Extended from Lawless & Pellegrino, 2007)

2.3 Review of the Literature: oTPD Research from 2007 to 2017

Two significant reviews of oTPD programs have been conducted in recent years. First, Lawless and Pellegrino (2007) surveyed empirical studies on technology-based professional development to examine how the PD interventions and research methodologies were structured in studies to date. Additionally, they sought to synthesize the empirical findings of the PD research community. However, they concluded that inconsistencies were evident across the field's collective body of work in three areas: (1) that there was substantial variation in how research was designed, often in ways that did not meet the measures of rigor defined by the research community; (2) that scholars lacked agreement on what designs or technologies work best in PD to meet certain goals; and (3) that when taken as a whole, the body of technology-based PD research had few synthesizable empirical findings on what works or why.

In a similar approach, the review by Dede et al (2009) reviewed oTPD programs specifically to identify how studies to date had met the research goals and challenges set by the community. Similar to that of Lawless and Pellegrino, their conclusion found that the literature exhibited a broad selection of research goals and findings. Many of the oTPD studies additionally failed to address the unique challenges posed by the research community for conducting research of oTPD programs. In addition to the lack of evidence and consensus on PD design in both of the above-mentioned reviews, the technological landscape has also significantly shifted and likely influenced the design and efficacy of oTPD.

Alongside the introduction of modern mobile devices in 2007, substantial technological shifts include the advent of online social networks and media, the proliferation of internet-connected mobile phones, tablets, and computing devices, the growing popularity of online games and massive online virtual worlds, the growing ubiquity of internet access and connected devices via the internet of things, and the surge of massive open online courses and other forms of distributed online learning. Each of these changes over the last decade has had potential to alter the fundamental ways in which professionals interact and learn. Due to the substantial number of technological advances in the last decade, a new review of the research trajectories and findings of oTPD studies is timely.

Literature review procedure. In Section 3, a collection of empirical oTPD studies from 2007 to 2017 were systematically reviewed using the three-layered evaluatory framework discussed in Section 2.6. The ten most recent years are specifically examined because of the significant technological changes and ubiquity of web-connected devices that have occurred in recent years, such as the advent of online social media, mobile smartphones, and widely accessible wifi and data networks. In addition, the two most recent reviews on technology-based PD for teachers examined studies up to 2007 (e.g., Dede et al., 2009; Lawless & Pellegrino, 2007), meriting a renewed examination of the field's advances.

Peer reviewed journal articles that focused on an empirical oTPD intervention were evaluated to (1) examine what advances the field has made in intervention and methodological design, (2) identify the oTPD features that have been implemented in programs based on features that are known to lead to "good" PD, (3) determine how effective oTPD programs have been at realizing teacher development and student achievement, and (4) determine the degree to which the issues and challenges raised by the research community have been addressed within studies over the last ten years. As online, mobile, and social interactive technologies mature and as connected digital technologies become further ubiquitous in educational settings, regularly identifying the direction that scholars have taken with research regarding oTPD and prioritizing the research challenges that remain to be addressed will be essential for the field's continued success.

In August 2017, a citation search was conducted using The Web of Science (by Clairivate Analytics, formerly ISI Web of Knowledge, www.webofknowledge.com). Any citations and abstracts that were delivered for the following search string were examined for initial inclusion: `[("Professional development" OR pd OR oTPD) AND (online OR internet)]`. 1032 citations were found with this search. To be considered for inclusion in this review, an oTPD study was required to meet each of the following criteria:

(1) be from a peer-reviewed journal;

(2) be an oTPD program (as defined in Section 2.1) that is designed for currently practicing K-12 teachers (i.e., primary and secondary teachers and not pre-service teachers); and

(3) be an *empirical* investigation, that is, must have analyzed data collected from an actually implemented oTPD program.

The formality of a program (e.g., an informal learning community, sponsored PD workshops) or its duration (e.g., one-shot, one-year, ongoing) were not criteria for inclusion and were equally added to the study if they met the criteria in the paragraph above. Papers without empirical analysis were not sufficient for inclusion, such as those that only forwarded PD or oTPD frameworks, theoretical designs without data from an actual intervention, literature reviews, or investigations of teacher perceptions and beliefs about PD in general without a specific PD in which subjects participated. As oTPD programs are the focus of this study, multimedia or computer-based PD approaches were not sufficient in and of themselves. Instead, it was required that multimedia-based programs to have participant interactions that were conducted over the Internet to some degree. Hybrid PD programs that used both face-to-face and online interactive components were included in the study if the selection criteria were met. Finally, the subject matter or content of the oTPD, or specific K-12 grade level taught by the participants in a study (e.g., elementary, middle) were considered for inclusion in the review if the selection criteria were met.

An initial review was conducted of the abstracts of the 1032 citations from the search for evidence of the review criteria. The initial collection of 1032 papers was reduced to 95 for closer review after the titles and abstracts were determined to either sufficiently meet the inclusion criteria or did not clearly merit rejection at the initial review. The largest rejection reason was that papers were largely focused on professional development for careers other than K-12 teaching (e.g., medical, higher-ed, legal). A second prominent reason for rejection was that studies were not empirical, but instead discussed professional development at a theoretical or survey level. After a thorough reading of each of the narrowed collection of 95 studies, a final count of 54 studies met all of the inclusion criteria. The 54 studies were subsequently analyzed using the three areas of evaluation discussed in Section 2.

oTPD studies were published in peer-reviewed journals each year since 2007. Although studies are well-represented in each year over the decade, a higher frequency of studies was published in each the most recent years compared to early in the study period. Figure 2 illustrates this distribution of the frequency of studies by year.

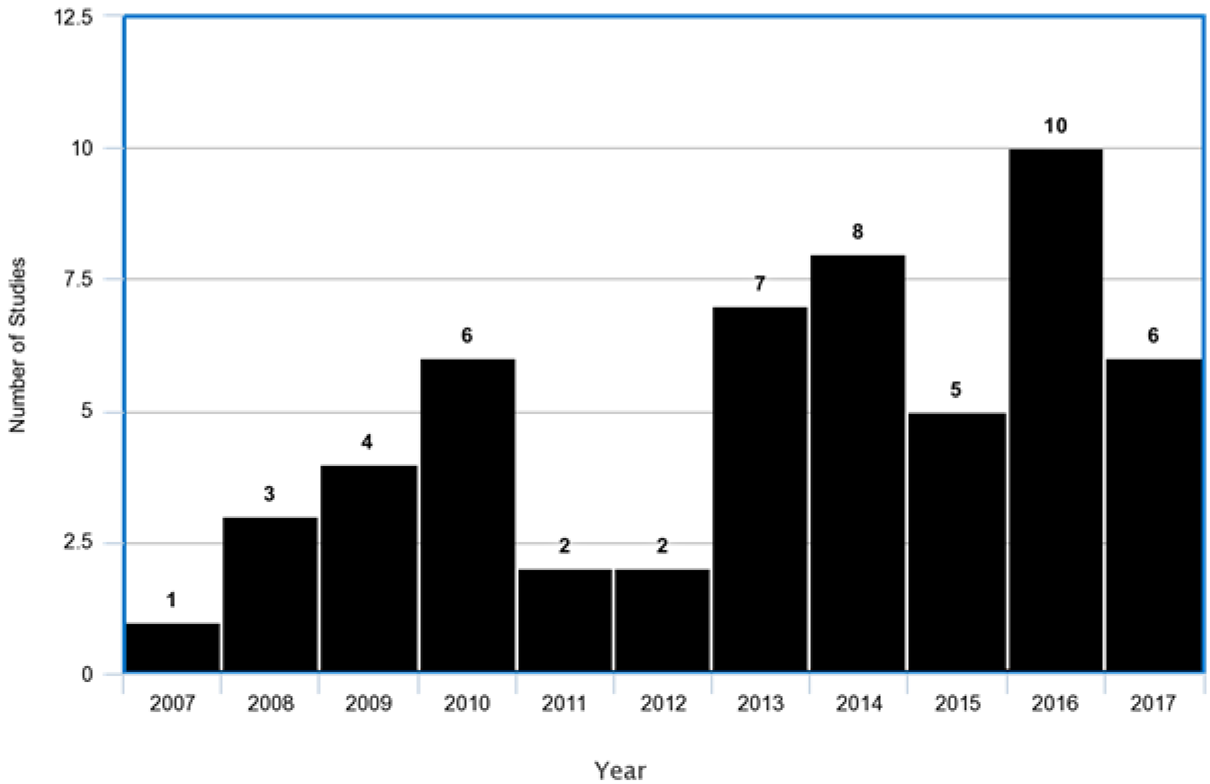


Figure 2. Frequency of oTPD studies, by year

In the sections that follow, I review the previous ten years of oTPD research in the contexts of each of the three general evaluative focal areas discussed in Section 2. For each subsection that follows, studies are categorized based on similarities, and multiple exemplar studies from each category are described.

2.3.1 Structural Elements of oTPD Programs between 2007-2017

2.3.1.1 Goals of oTPD Programs

Over the previous decade, oTPD programs have been designed with multiple goals to promote the professional growth of teachers. It is well accepted that the goals of a PD intervention is the foundation upon which outcomes and subsequent research questions about process and efficacy can be investigated (Borko, 2004; Desimone, 2009; Wayne et al., 2008). Taking an inventory of the most recent years' oTPD goals is useful first step for understanding the direction that the field has taken toward identifying "what works and why" (Lawless & Pellegrino, 2007). To this end, multiple studies established goals to promote teacher professional growth in knowledge and practice, as could be expected based on prior reviews on PD and oTPD (e.g., Dede et al., 2009). In addition, a substantial number of studies stated goals toward promoting teacher behaviors that occur specifically within PD activities that are thought to be beneficial to learning. However, such PD-specific behaviors were less concerned with the subject content or classroom practice goals that commonly underlie PD programs but instead expressing goals that specifically promoted positive PD behaviors among participants. The many layers of PD program goals that were observed can ultimately influence participants at different points of their practice, including during PD activities and in the classroom. In this section, the goals that were specified by authors of oTPD programs from 2007 to 2017 are consolidated into five general categories based on goal or content similarity. As an oTPD program could exhibit multiple goals, studies could belong to more than one category. Table II summarizes the observed categories of oTPD program goals.

TABLE II

OBSERVED STATED GOALS AND CONTENT OF OTPD PROGRAMS, 2007-2017

Goal	No. of Studies	Description
Knowledge and affective goals	17	Primary goals of the oTPD program to promote knowledge growth (e.g., content knowledge, familiarity with curriculum) or positive affective outcomes (e.g., self-efficacy, interest).
Pedagogy and implementation practice goals	11	Goals to influence behaviors of teachers; to promote certain pedagogical practices or the implementation of curriculum.
Technology practice goals	11	Goals to promote skills and use of specific technologies.
PD interaction goals	31	Goals to encourage teachers to interact in the PD program in specific ways (e.g., discussion, reflection).
Ad-hoc goals	15	Goals are undefined at the development stage; goals are defined by participants as they join and engage in activities,

Knowledge and affective goals. Within the first category of *knowledge and affective goals*, 17 oTPD studies expressed goals or included instructional material in an oTPD program that promoted the development of teacher content or pedagogical knowledge, or intended to bring about shifts in teacher dispositions, affect, or beliefs. In general, the oTPD programs in this category were concerned with providing teachers with opportunities to build knowledge and gain familiarity with new concepts, pedagogical strategies, or disciplinary content as new information in the field or research becomes available. As a typical example of knowledge-based goals, Shea, Mouza, and Drewes (2016) provided an oTPD program to teachers to promote development of climate change content knowledge for use in science courses, as well as information on approaches to teaching about climate issues. Similarly, the oTPD reported by Wang, Hsu, Reeves, and Coster (2014) was designed to provide teachers opportunities to learn about and gain familiarity with concepts related to new literacies, digital media, and approaches to using inquiry skills in the classroom. El-Hani and Greca (2013) also regularly distributed on-demand information about student-centered pedagogical approaches to teachers to help them develop their knowledge during oTPD participation. These examples illustrate the common goal of oTPD to impart information to teachers and develop their knowledge on the topics of study.

Related to the development of teachers' knowledge on various topics, some oTPD programs also sought to promote positive beliefs about and dispositions toward disciplinary subjects and pedagogical approaches. For instance, Moore, Haviland, Moore, and Tran (2016) reported on an oTPD that was designed around a goal to increase teacher self-efficacy and positive beliefs around the use of GIS technologies in the classroom. In an second example, Wang et al. (2014) encouraged the development of teacher self-regulation and planning skills with an informational resource database to be used in their everyday practice. Additional affective goals that were observed included the development of positive attitudes toward pedagogical practices (Marrero, Woodruff, Schuster, & Riccio, 2010; Owston, Sinclair, & Wideman, 2008; Seraphin, Philippoff, Parisky, Dengan, & Warren, 2013; Walker, Recker, Ye, Robertshaw, Sellers, & Leary, 2012) and the development of teachers' identities, such as teachers seeing themselves as technology innovators or leaders in their schools (Ching & Hursh, 2014; Hanuscin, Cheng, Rebello, Sinha, & Muslu, 2014).

Pedagogy and implementation practice goals. The second observed category, *pedagogy and implementation practice goals*, is composed of 11 studies that were intended to affect changes in teacher behaviors related to pedagogical practices and teachers' implementation of curricula (as opposed to developing general knowledge about skills and behaviors). Over the last decade, oTPD programs were commonly offered alongside new curriculum or standards reforms. In these cases, oTPD was intended to promote teacher implementation of pedagogical approaches or curricular activities with a high degree of fidelity (Donnelly, & Boniface, 2013; Fishman et al., 2013; Riel, Lawless, & Brown, 2017). Exemplifying these behavior-based goals are those outlined by Fishman et al. (2013), in which the oTPD reported in their study promotes the use of observable student-centered pedagogical approaches and practices related to the curriculum that they were helping teachers enact. In effect, they sought to encourage a high degree of curriculum implementation fidelity as a result of oTPD participation. To this end, Fishman and colleagues sought to affect demonstrable changes to teacher classroom practices with their oTPD by having teacher participants actually perform classroom activities with support from the PD providers and by giving teachers chances to analyze the outcomes of their practice. In addition to this example, multiple oTPD programs sought to promote certain pedagogical approaches within oTPD programs (Berger, Eyelon, & Bagno, 2008; Cho & Rathbun, 2013; Masters, de Kramer, O'Dwyer, Dash, & Russell, 2010), as well as the implementation of specific in-class activities as parts of novel curricula (Donnelly & Boniface, 2013; Seraphin, Philippoff, Parisky, Degnan, & Warren, 2013).

Alternatively, some oTPD programs had goals that promoted teachers' preparation practices that take place before instruction, such as the reflective planning and adaptation practices that were encouraged within the oTPD by Polly et al. (2016). In this program, Polly and colleagues' specified goals were to promote positive changes to teaching approaches that can occur only after teachers had a chance to try activities in the classroom and use the outcomes from the classroom to reflect on their subsequent plans. Similarly, the oTPD by Walker et al.

(2012) emphasized teachers' out-of-class use of online resources and materials shared within an online community of teachers to promote teachers' creation of custom lessons and class materials. Thus, in addition to in-classroom practice, the promotion of beneficial pre-classroom preparation practices of teachers were also valuable goals among oTPD providers over the last decade (El-Hani & Greca, 2013).

Technology practice goals. The third category, *technology practice goals*, represents 11 studies that promoted teachers' familiarity and use of novel technologies or technological processes in the classroom. Albeit similar to the goal of teacher pedagogical practices, this set of goals is particularly focused on developing teacher expertise of assistive digital tools that would be used with students, ancillary to curricular or pedagogical practices. For instance, the oTPD by Moore et al. (2016) provided a significant focus on teachers' use of geographic information system (GIS) and cartographic technologies to support a variety of curricular activities in social studies and science. Similarly, Shea et al. (2016) promoted in their oTPD teacher familiarity with climate data and mapping technologies to support a range of curricular goals related to climate change, ecology, and general science. However, personal skill with technology is often not sufficient in itself. The goals of the program by Ching and Hursh (2014) emphasize the additional need for teachers to have skill in modeling the use of assistive technologies for their students, which can be developed during oTPD among groups of teachers through peer modeling and demonstration.

PD interaction goals. Comprising the largest proportion of observed goals, the fourth category *PD interaction goals* consists of 31 studies that specified goals intended to promote positive teacher behaviors solely during activities within an oTPD program. To this end, the most frequently promoted of these behaviors were those related to social and community-based interactions between oTPD participants. As an example, the oTPD by Prestridge (2010) had a specific goal to promote collegial dialogue and sharing among participants. Similar goals were expressed in the oTPD by Gu, Zhang, Lin, and Song (2009), as the authors encouraged teachers' support of each other during PD through activities for participants to gather and share resources related to issues being faced in the classroom. Finally, like many other studies in this category, Chai and Tan (2009) expressed a desire the outset of the oTPD design to encourage collaborative knowledge building in the oTPD from their study and embedded these goals into the activities they designed.

However, from a more individual participant perspective, some studies in the PD interaction goals category also focused on personal actions that supported PD participation. For instance, studies by El-Hani and Greca (2013) and Dalgarno and Colgan (2007) had activities specially designed to meet goals that addressed teachers' personal logistical needs as they emerged as they participated in the PD. In these studies, the oTPD activities or content could change based on teachers' needs, or the types of expected interaction by individual participants could be personalized to make participation easier. From an alternative perspective, studies by both Chai and Tan (2009) and Kale, Brush, and Saye (2009) addressed the need for productive PD practices. This was accomplished in these studies by embedding activities that supported critical thinking, reflection, and desirable types of participation by teachers as they engaged in the PD activities. Finally, Gamrat, Zimmerman, Dudek, and Peck (2013) specified goals for participants that encouraged them to make productive decisions while using the oTPD program. To meet this goal, Gamrat and colleagues implemented a digital badging system to provide teachers an enhanced awareness of the level of their participation, engagement, and decisions that they made during the oTPD. In combination, studies within this category were often more concerned with promoting activities or other interactions that take place only during oTPD programs and had less emphasis on content-related goals. This category represents an important set of goals, as PD programs that have weak or no participation can all be guaranteed to have no effect on teachers or students (Guskey, 2000; Hrastinski, 2009).

Ad-hoc goals. Finally, a fifth category called *ad-hoc goals* was observed in 15 studies within, which the goals of the oTPD program were intentionally not set ahead of time when the oTPD was designed. Instead, the oTPD providers would address the specific goals and project ideas that teachers brought to the oTPD as they joined and participated in the PD. Instead of specific objectives to be achieved at the time of oTPD recruitment, the foci were instead the development of a community of learners and a promise to collaboratively engage in activities and goals decided by the group that formed. One instance of this type of ad-hoc goal-setting was reported by Salmon, Gregory, Dona, and Ross (2015) in which participants were encouraged at the first moments of the oTPD to share their experiences, classroom challenges, and knowledge on challenges to set the agenda for the remainder of the program. Similarly, Ostashewski, Moisey, and Reid (2011) employed an online social network for their oTPD in which activities and topics for discussion were drawn from the everyday posts by participants only after they joined the community. In a broader context, Rolando, Salvador, Souza, and Luz (2014) reported an oTPD that offered no specific goals to participants at the time they joined the program but emphasized the ability to leverage a strong community of biology educators with whom problems could be posed and solved. These examples are just some of many that were observed that offer participants with open-ended activities or undefined goals and encourage participation by emphasizing the depth of the participating teacher community and presence of structured activities once goals are established by the group (e.g., Cavanaugh & Dawson, 2010; Owston, Sinclair, & Wideman, 2008). OTPD programs are indeed well-poised to meet the needs of teachers as they emerge by using web-based technologies to offer robust methods for communication and a strong foundation for communities of teachers in ways that are still new to the field (Barab, King, & Gray, 2004; Ho, Nakamori, Ho, & Lim, 2014; Rolando, Salvador, Souza, & Luz, 2014). However, it remained to be seen in these studies that if a goal-agnostic approach and a predominant focus on PD recruitment led to the achievement of ad-hoc goals. To these ends, the achievement of ad-hoc goals in OTPD programs is a valuable focus for future research.

The essential goals for oTPD outlined by the research community have been well represented by the five observed categories of goals in this review. However, not all of the oTPD program goals that have been previously emphasized by the field of PD researchers were observed. Student achievement is typically an assumed distal outcome of PD programs, but only one study in this review expressed such goals. Although students naturally did not directly participate in the oTPD designed by Fishman et al. (2013), the program was specifically intended from the outset to improve students' subject knowledge and disciplinary skills that are associated with curricula that the students' teachers were learning how to implement in the oTPD program. Despite being the sole example of expressing student achievement as part of the up-front *goals and design* of oTPD programs in this review, the program designed by Fishman and colleagues is a valuable exemplar for future studies in the specific consideration of student achievement in the design of oTPD programs. Movement in a similar direction will continue to advance the field's research agenda toward identifying what works and why in oTPD for both teachers and students.

The specification of goals in oTPD programs is the essential first step toward identifying whether oTPD programs are addressing the realistic issues that teachers encounter in their everyday work. Although the specification of goals in itself does not provide the evidence of goal achievement and PD program efficacy that has been demanded by the community, it is an important aspect of PD structure and design that has been frequently neglected in research reports (Guskey, 2000). Specification and measurement of the goals of PD programs are an essential component of measuring program efficacy. With the new trends of ad-hoc and flexible goal setting that have emerged in recent years, extra care will be needed to track the establishment and shifting of goals through a program's duration. In summary, the previous ten years of oTPD research has reflected multiple critical learning goals that are important to teachers. These goals reflect the commitments of the research community toward supporting teachers' ability to implement reforms, including the more nuanced approaches to supporting teachers' personal needs *as they emerge* through ad-hoc goal establishment in ongoing PD programs. Therefore, extra care has to be made within the design of programs to support the flexibility of content and activities to meet the demands of both pre-established and shifting goals.

2.3.1.2 <u>Theory-Based Design Features and Approaches to Their Implementation</u>

oTPD providers implement design features and activities that will realize the goals established for the oTPD program and maximize learning. To this end, varied design features were observed in oTPD studies over the last decade. Although the PD research community generally agrees on the features that maximize professional learning, the approaches used to implement these features were highly varied. With today's digital ecosystem offering myriad technologies and activities that can be implemented, an inventory of design features in oTPD from the previous decade provides timely and valuable design knowledge to providers of oTPD, as well as highlights the collective theoretical commitments of the field (Rice & Dawley, 2009). In addition, the specification of design features in oTPD literature is essential for comparison of oTPD programs, as it is difficult to reliably investigate the differences between interventions with either entirely different or unknown features (Hochberg & Desimone, 2010; Wayne et al., 2008). In this section, the presence of design features and how they were implemented in each study were evaluated based on the five types of features that have been deemed essential for PD design by the research community, as described in Section 2.1. The categories of observed design features in reviewed studies are additionally summarized in Table III.

Social Learning. Social learning features were those most frequently observed in this review. 40 studies reported the implementation of social communications and sharing activities that were mediated by web-based technologies. This large number of studies with social features also exhibited the implementation of social interactions in substantially varied ways. Foremost, multiple scholars intended for the social communication tools in oTPD to provide the opportunity for teachers to form engaged communities within which they could work together to achieve common goals and learn from each other, such has been suggested in the work of Barab, King, and Gray (2004), DuFour and Eaker (1998), and Wenger (1998). Many of the social communications tools implemented by studies in this review were often intentionally left open-ended to encourage their use outside of any scheduled or prompted social or discourse-based activities.

TABLE III

OBSERVED DESIGN FEATURES IN OTPD STUDIES, 2007-2017

Design Feature	No. Studies	Description
Social learning	40	Participants interact with other people, particularly other professionals or experts in the field. Interaction with others that are at the same level as the participant, as well as those more experienced than the participant. Social interactions help participants collectively make sense of phenomena and information.
Instructional resources, information, and multimedia choices	37	Multiple on-demand resources and media are available to help teachers better understand content and provide support to teachers when needed. Media choices help communicate meaning in different ways. Teachers learn well both structural supports and cognitive tools to achieve PD objectives.
Active learning	28	Program activities should consist of teachers' active engagement, as opposed to passively receiving information.
Authentic learning experiences	28	Activities are embedded in teachers' everyday work, tasks can be directly used in classroom and school contexts. Teachers bring their everyday work, knowledge, beliefs, and prior experiences to learning opportunities, which will influence how they make sense of information and interact.
Reflective activities	12	Insights are gained by reflecting on and evaluating prior experiences. Reflection can reveal new connections, things to try in practice, and opportunities for improvement. Shifts can occur in a teacher's knowledge, skills, beliefs, interests, goals, and identities as they evaluate their experiences.
Studies lacking feature specification	8	Little to no specification on design features or their implementation was provided.

Multiple oTPD designers who adopted this strategy anticipated that the use of open-ended community spaces could encourage teachers to flexibly and collaboratively solve challenges as they arise and develop collegial relationships outside of structured PD activities (e.g., Bates, Phalen, & Moran 2016; Duncan-Howell, 2010; Kellogg, Booth, & Oliver, 2014; Moore 2016). As an example, Albers, Pace, and Odo (2016) created multiple digital spaces for teachers to interact in the oTPD to meet other teachers and interact, such as the simultaneous use of message boards, private messaging, and image and video sharing capabilities to meet teachers' correspondence needs and interests. Through another approach, Qasem and Viswanathappa (2016) integrated an online social network into the regular activities of their oTPD and encouraged teachers to use the network in an open-ended way to communicate, share information, and support each other's learning. To this end, the use of new technologies for participant social interactions was occasionally observed, such as with the use of social networks (Rolando, Salvador, Souza, & Luz, 2014; Ostashewski, Moisey, & Reid, 2011). However, classic online message board and forum technologies were the most popular formats used among oTPD designs that implemented social features (e.g., Al-Balushi & Al-Abdali, 2015; Martin et al., 2016).

Despite the potential benefits of open social spaces for teachers to interact and collaboratively solve problems, multiple authors commonly reported limitations of open-ended or unstructured social interactions in that they often failed to realize any substantive discussions or contributions by participants (Marrero, Woodruff, Schuster, & Riccio, 2010). In recognition of this limitation, structured social activities were also frequently observed as part of oTPD offerings to encourage participation. Structured social features took many forms, which included the facilitation of scheduled online discussions among teachers in breakout groups (Hjalmarson, 2017; Salmon, Gregory, Dona, & Ross, 2015), synchronous instant messaging chats and interactive webinars among participants (El-Hani & Greca, 2013), periodic message board and forum posting expectations (Al-Balushi, & Al-Abdali, 2015; Martin et al, 2016), regularly scheduled sharing of resources found on the Internet and examples from actual classroom experiences (Ho, Nakamori, Ho, & Lim, 2016; Polly et al., 2016; Qasem & Viswanathappa, 2016), and the use of staff moderators to further engage participants after they initially post to forums (Hull & Saxon, 2009; Seraphin et al., 2013; Unwin, 2015). Although many studies in this review indeed offered open-ended community spaces, these types of desired interactions did not necessarily happen organically, especially as the communities were in the early stages of formation (Schlager & Fusco, 2003). To address this challenge, an expectation of social interaction through structured activities was implemented by the above-mentioned oTPD providers to impress on participants that social interaction was a condition of participation.

The use of mentoring and coaching with non-participant experts was also an important social feature in oTPD, which was implemented 10 of the studies. These arrangements were moderated through both on-demand direct communications media (e.g., email, instant message) and conventional asynchronous message boards aimed toward use by the whole community. Using these technologies, participants could interact with content experts and other more experienced teachers on the material being studied in the oTPD. Notable examples from the studies in this review included (a) an oTPD by Cavanaugh and Dawson (2010) where participants could privately message science experts when needed; (b) a program by Kale, Brush, and Saye (2009) in which teachers were contacted regularly by more experienced teachers to ask them about their thoughts on the connections between the PD and their classroom practice; and (c) an oTPD reported by El-Hani and Greca (2013) where participants and experts both discussed topics on a forum to support collaborative knowledge creation and the development of science pedagogical content knowledge to support local classrooms.

In addition to discourse-only social activities between participants, teachers in six oTPD programs collaboratively developed usable tools for classroom use and other knowledge objects that would persist after the PD was over. In one instance, Chen, Jang, and Chen (2015) expected teachers to collaboratively build a wiki over the course of the oTPD, which would be used to describe and analyze phenomena that teachers experienced in the classroom while teaching science. In another example, El-Hani and Greca (2013) requested that teachers collaboratively develop a wiki, as well as a group blog to document the activities in the PD. Similar to the creation of long-lasting projects, teacher participants in four of the oTPD programs from this review recorded actual classroom teaching sessions and shared these recordings with other teachers for annotation, evaluation, and discussion (Hjalmarson, 2017; Owston, Sinclair, & Wideman, 2008; Zhang, Liu, & Wang, 2017; Zhang, Liu, Chen, Wang, & Huong, 2017). As participants collaborated on creative media projects, social interaction and communication were necessary conditions for successfully completing projects. As a result, socially creative works and group analysis of media objects added additional avenues for teachers to learn together outside of activities that were focused solely on discourse.

A novel approach to encourage social interaction that has risen to prominence in the previous decade is the use of hybrid (or blended) format programs. Often cited as a method for increasing the the potential for social learning, hybrid programs are defined by having implemented both face-to-face and online components (Matzat, 2013; Owen, 2017; Walker et al., 2012). With the primary intent to maximize social benefits of face-to-face interaction 17 of the reviewed studies were structured in a hybrid (or blended) format. One commonly observed hybrid model was implemented through the use of traditional face-to-face graduate-level courses for practicing teachers (e.g., Chen, 2015; Ching & Hursh, 2014). Similar to traditional university courses, Shea, Mouza, and Drewes (2016) described an informal one-year oTPD in which face-to-face meetings were scheduled to occur multiple times to compliment the ongoing online experience and improve the camaraderie of the group. This staggered face-to-face meeting approach was used by other informal hybrid oTPD programs as well (e.g., Moore, Haviland, Moore, & Tran, 2015; Polly et al., 2016). However, in contrast to regular face-to-face meetings, some other hybrid oTPD programs only used a single up-front face-to-face experience to prepare participants for long-term web-based interactions (Hanuscin et al., 2014). One illustrative example of this is the program by Fishman et al. (2013), which provided an up-front face-to-face workshop to offer training with the technology environment that participants would use in their forthcoming oTPD and ensured that participants were otherwise prepared for the upcoming weeks of the program. In general, designers of hybrid programs expressed intention to promote social learning and engagement among participants by leveraging the benefits of physical presence to some degree. As a result, complimentary in-person meetings were frequently used as they are thought to provide greater context for interacting with other participants and offer memorable, focused in-person experiences (Berger, Eyelon, & Bagno, 2008; Hjalmarson, 2017; Marrero et al., 2010).

Instructional resources, information, and multimedia choices. The second-most frequent feature to be implemented in oTPD was the commitment to providing informational resources and participant supports using multiple complementary media. 37 programs provided such pre-made instructional media and information sources to participants. Representing the most frequently observed format of informational resource delivery in studies was through instructional media or tutorials within course sequences or modules. For instance, Cavanaugh and Dawson (2010) provided sequences of video lessons to participants on pedagogies for teaching science, which were accessed one after another and each video lesson built upon previous content. In the same way, Graham and Fredenberg (2015) provided a series of instructional tutorial videos and texts on how to plan and teach using connectivist principles in participant teachers' classrooms. The instructional materials and informational resources used to implement this feature often closely mirrored that of traditional classroom education, with participants interacting with texts and media to learn about ideas and skills related to teaching.

However, in some programs, instructional media were not intended to be linearly sequenced or accessed in a specific order, as researchers and developers often assumed that teachers' needs might arise unexpectedly, or teachers might independently desire additional information as they progress through oTPD activities. In the most prevalent example of on-demand, instant-access informational support, 27 programs reported that a browsable repository of informational resources was provided with which participants could browse and use materials at any time, in any order based on their needs. In these cases, information was sorted using categorization approaches to help with browsing, such as by tag, topic, author, or expertise level, were also sometimes searchable using keywords (Gu et al., 2009; Walker et al., 2012), and provided participants with the capability to view, manipulate, annotate, and archive informational resources (Ostashewski et al., 2011).

The reviewed programs also often delivered informational resources through multiple media formats. These media include video lectures in both pre-recorded and live formats (Hjalmarson, 2017; Seraphin et al., 2013; Zhang, Liu, & Wang 2017); interactive quizzes and polls within course sequences (e.g., Rolando et al., 2014), printable materials to help teachers as they perform PD activities, such as worksheets and organizers (e.g., Malanson et al., 2014), and instructional or tutorial "how-to" documents for using technology or teaching lesson plans (e.g., Seraphin et al., 2013). To this end, many of the observed studies have employed the same web-based media that have been common components in online courses over the previous two decades.

Despite an abundance in multimedia resources in oTPD programs, Jimenez and colleagues (2016) emphasized the importance of not just providing different forms of media as a matter of principle. Instead, they held the assumption that providing multiple media representations on the same topic, but with each media choice covering material in a slightly different way, can be used to maximize learning by leveraging the strengths of each media choice to effectively communicate ideas. To meet this commitment, Jimenez et al. provided informational resources with differing media covering the same topic. However, each media format provided different, but complementary information to the other formats. The goal was not to provide duplicate information across formats but tell stories and deliver information about topics in ways that maximize the potential of a given format, such as video providing visual representations and multiple nonverbal cues, while text provides rich descriptions using language. Cho and Rathburn (2013) and Fishman et al. (2013) echoed this sentiment, as their oTPD programs provided informational content on the same topic by using multiple parallel complementary media that could all be used by participants without the feeling that each media choice duplicated other choices. In other words, the authors of these programs hold that ideas can be communicated differently via different media, and multiple media used in combined way can help learners create a clearer understanding of what is being conveyed (Kozma, 1991; Morrison, 1994).

Finally, 12 programs embedded both synchronous and asynchronous dedicated staff support mechanisms. Dedicated staff support was offered as an on-demand information resource focused on the operation and logistics of the PD, monitoring teacher participation, responding to PD participation challenges that were encountered by teachers, and encouraging participation if teachers were not active for some time. For instance, Rolando et al. (2014) monitored the levels of participation in their program based on number of posts in forums and subsequently offered check-ins and guidance to participants from tutors to those with lower participation levels. Similarly, Cho and Rathbun (2013) monitored the participants' levels of activity, specifically their click and submission frequency. If participation was low, they reached out to participants and offered support and encouragement. In the reviewed programs, a dedicated staff presence was readily available to help participants on social media (Ostashewski, Moisey, & Reid, 2011), message boards or forums (Hull & Saxon, 2009; Wang et al., 2014), and live chat or scheduled interactions (Albers, Pace, & Odo, 2016; Malanson et al., 2014). Because oTPD occurs online, active participation is essential to ensure that the program will have any benefit. In summary, oTPD programs that have dedicated support staff can promote successful operation of the program and increased participant satisfaction by ensuring that participants can easily interact with the program and that logistical challenges are readily solved (Cho & Rathbun, 2013; Hull & Saxon, 2009; Kale, Brush, & Saye, 2009).

Active learning. Active learning was the third most frequent design feature employed by oTPD researchers in the reviewed studies. Similar to social learning, the principle of active learning engages participants by using instructional materials and media through some kind of project instead of simply passively receiving the information without any application. Authors of 28 studies stated that active learning principles were included in the design of oTPD. This feature was almost universally implemented as activities where participants created useful items or tools that they could use in their classroom. The most frequent example of this was through the creation of lesson plans by using information and media obtained during the oTPD. In many programs, such lesson plans were written individually by teachers for use in their individual classroom. However, Walker and colleagues (2012) emphasized that teachers need to be active creators during PD in any way possible, even if not creating new products. To this end, they encouraged teachers to write lesson plans and other materials for use in the classroom, but also emphasized other creative work, such as making adaptations to existing plans based on what was experienced during the PD. Although plans were often written individually, in some cases these lesson plans were additionally shared with other participants with the expectation of feedback. Examples of this include the oTPDs by Shea, Mouza, and Drews (2016) and Salmon, Gregory, Dona, and Ross (2015), where teachers would submit lesson plans to a discussion forum and other participants would provide feedback toward plan revisions.

Additional classroom tools that were developed by teachers during PD included worksheets and graphic organizers (Gu, Zhang, Lin, & Song, 2009; Polly et al., 2016), written reports and interpretive activities related to classroom data or outcomes (Qasem & Viswanathappa, 2016; Rolando, Salvador, Souza, & Luz, 2014), and written blog posts that report activities, events, and outcomes in teachers' classrooms (Graham & Fredenberg, 2015; Hanuscin et al., 2014; Ming, Murugaiah, Wah, Azman, Yean, & Sim, 2010). It is evident that the focus of the designers committed to implementing active learning features have emphasized the creation of useful items for participants instead of simply providing them information related to the topic of study.

Although the creation of useful items is the predominant feature associated with active learning, some studies additionally exhibited innovative approaches to actively engage participants. In one example, to demonstrate novel pedagogical approaches, the program by Seraphin et al. (2013) had structured activities where teachers would use the very pedagogical strategies that were being studied by participants in the oTPD. Teachers taught small lessons to each other using the procedures they would be subsequently attempting in their work with students. Although this is not necessarily a novel educational approach to promote active learning, this uniquely observed experience in an oTPD was cited as providing teachers with direct, active experiences with new skills and real-time feedback from facilitators. From a different perspective, Berger, Eyelon, and Bagno (2008) promoted active learning by requiring participants to find and share informational resources related to the PD, then subsequently analyze and critique these informational resources. In contrast to simply consuming media and informational resources, Berger and colleagues had participants instead create new knowledge from media by actively analyzing web resources found by the group for strengths, shortcomings, and potential for classroom application. In all, the multiple approaches in these studies represent the commitment by scholars to innovatively approach the challenges of interactivity in oTPD and leverage the unique ability for web-based technologies to connect participants to people and information.

Authentic learning experiences. Well-represented within the reviewed studies was the commitment to authentic learning experiences. As part of authenticity, experiences should be well-aligned to teachers' everyday work. 28 studies exhibited design features intended to help teachers put activities directly into practice and use their classroom experiences, the needs of their students, and the challenges they encounter to place oTPD learning activities in the context of teachers' practice.

oTPD programs that specified authentic learning features predominantly used teachers' personal experiences as the context or set the agenda for activities (21 studies). Similar to the activities observed with active learning features in the above section, some oTPD designers merged active learning generative activities with authentic learning principles. This was commonly done by requiring participants to create resources and tools that can be used in their personal classroom. Examples of this approach included teachers' creation of lesson plans and organizing tools (Ching & Hursh, 2014; Gu et al., 2009; Wang et al., 2014), the development of learning activities that link to educational standards used in the classroom (Cavanaugh & Dawson, 2010; Polly et al., 2016), and the recording videos of teachers' classroom activities to be used as discussion cases by colleagues in the PD (Bates, Phalen, & Moran, 2016; Ming et al., 2010; Unwin, 2015). To this end, Berger, Eylon, and Bagno (2008) summarized well the need for authenticity in oTPD programs and how programs should hold a commitment to prioritizing the real, relevant reasons that teachers would participate in their oTPD program. In its most basic sense, they argued that oTPD has to ultimately help teachers do their work. In their program, activities were only subsequently constructed after teachers expressed the reasons they wanted to participate in PD, as well as the personal growth areas in which they wanted to see improvement. Such rapid, ad-hoc activity design is afforded by oTPD as the timing of participation c
an be more flexible than face-to-face programs.

Reflective activities. 12 of the studies featured activities that supported participant reflection, or the critical examination of past experiences to synthesize new inferences about practice and create new knowledge. Among the reviewed studies, self-reflective features were largely implemented as writing tasks that were prompted or regularly scheduled. These writing tasks typically encouraged participants to analyze and draw inferences from their teaching experiences or to evaluate the activities of the PD in which they were participating shortly after completion, which was mostly implemented on message boards or community forums (Shea, Mouza, & Drewes, 2016; Wang et al., 2014). In the program by Wang and colleagues (2014), participants could also receive comments and insights from peers in the PD course on their reflections through the use of threaded conversation and reply features.

However, message boards or forums were not the only technologies that were used by designers to promote reflective activities. Participants were encouraged to fill in online journals (Hjalmarson, 2017), post short reflections on PD activities on social media (Ostashewski et al., 2011), earn digital badges from completing and evaluating PD experiences (Gamrat et al., 2014), or receive automated notifications that remind participants to perform regularly scheduled reflections (Gu et al., 2009). Reflective features have not only been implemented by oTPD designers as scheduled or prompted activities, but also in recent years as functions of reminding and notifying teachers to reflect on their experiences to address challenges with participation in PD. This has been particularly true in the context of teachers increasingly busy schedules, particularly with routine activities like reflective prompts and journaling (Gu et al., 2009; Hjalmarson, 2017; Owston, Sinclair, & Wideman, 2008).

Studies lacking design specification. A challenge to the conduct of robust research in the oTPD field is the lack of specification in design features in formal reports. 8 programs lacked any specificity on the design features employed and descriptions on how any features were implemented other than that the program was conducted online. Although these studies were analyzed in this review, they unfortunately could not be included in this analysis with any substantial depth.

2.3.1.3 <u>Duration of oTPD</u>

As discussed in Section 2.2, PD scholars have generally agreed that PD programs should be of sufficient duration to promote long-term learning and the integration of new knowledge into practice. Because of the ubiquity of digital connectivity that can be achieved with web-based technologies today, oTPD providers have the potential to offer PD programs with either long-term or undefined durations. In the reviewed studies, a broad range of program durations was observed among oTPD over the previous decade. Figure 3 illustrates the variety in duration for oTPD programs that was reported in the reviewed studies.

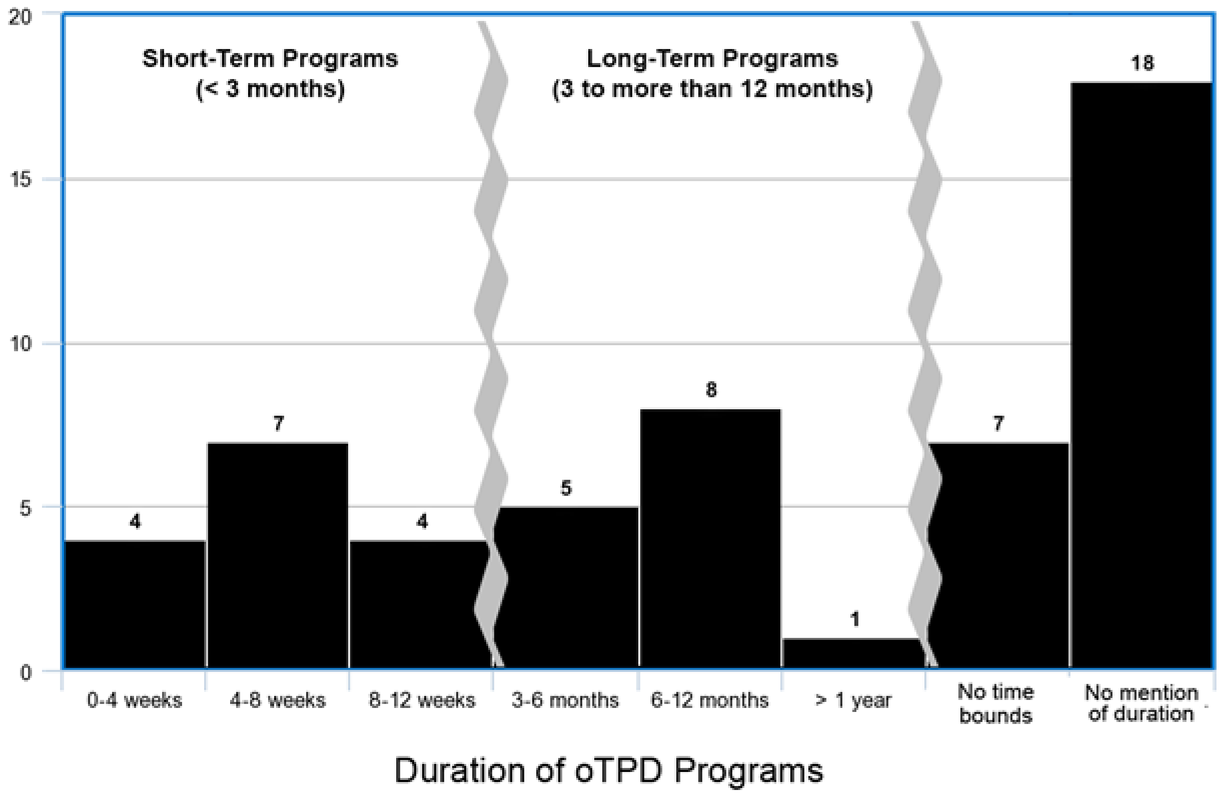


Figure 3. Histogram of oTPD duration of programs from 2007 to 2017, by number of weeks

In general, multiple studies reported programs that were truly long term in duration, with some lasting up to a year or more (Hanuscin et al., 2014; Masters et al., 2010; Martin et al., 2016; Unwin, 2015). Although web-based technologies afford the opportunity to operate long-term oTPD programs, a substantial number of programs also operated over a period shorter than three months or one academic semester, with short-term durations ranging from four weeks (Ching & Hursh, 2014; Sherman, Beyers, & Rapp, 2008, Zhang, Liu, & Wang, 2017) to twelve weeks (Hull & Saxon, 2009; Rolando et al., 2014; Walker et al., 2012). In addition, almost all of the reviewed programs were reported to have spread out interactions over multiple sessions instead of one single session or even a few. This is an important distinction, as some programs were designed to spread out participants' interactions over time instead of having participants interact at only one time, such as "one-shot" programs (Albers, Pace, & Odo, 2016; Shea, Mouza, & Drewes, 2016; Unwin, 2015).

Two similar trends that have emerged over the last decade related to duration are the rise of both open-timeframe and self-paced oTPD programs. First, with the rise of digital communities and spaces for ongoing interaction among practitioners, multiple programs did not place a bounded duration or schedule for the program. Instead, participants could interact with each other for as long as they desired, even indefinitely if enough interest was maintained. As a result, voluntary participation is often a distinguishing characteristic of open-duration oTPDs. Examples of these programs implemented open communities in multiple ways, which included the development of a teaching wiki as an environment (Donnelly & Boniface, 2013), discussion-based communities to regularly engage in topics that teachers encountered in their work (Duncan-Howell, 2010; El-Hani & Greca, 2013), and a social network where teachers' immediate questions and needs related to practice could be discussed among group participants (Ostashewski et al., 2011). The general goal of these programs was for open-duration PD communities to interact indefinitely and continue learning with structured activities for as long as teachers participated. In addition, because interest in the community was seen as a driving force behind participation, it was essential for activities to be motivating and valuable to teachers, else they would simply leave the oTPD program. It is then argued that these flexible, open-duration environments gave teachers relevant experiences that met their specific needs and time constraints (Ostashewski et al., 2011).

Second, although most oTPD programs employed bound timeframes, some allowed participants to work on projects entirely at their own pace with a low emphasis placed on the timeframe for completion, particularly with activities that used instructional media (Fishman et al., 2013; Marrero et al., 2010; Polly et al., 2016; Sherman, Beyers, & Rapp, 2008). Such asynchronous, self-paced oTPD allowed teachers the flexibility to complete activities according to their personal scheduling needs. Some programs also spread out multiple self-paced scheduled activities over longer periods of time to encourage ongoing participation in lengthy oTPDs. Such activities included regularly scheduled synchronous follow-up meetings with facilitators or peers (Francis-Poscente & Jacobsen, 2013; Martin et al., 2016; Walker et al., 2012) and the ongoing introduction of new topics through activities or instructional course modules each month (Albers, Pace, & Odo, 2016; Unwin, 2015). Similar to open-duration programs, the observed examples of self-paced oTPD allowed participants a great range of flexibility in their interaction with instructional materials and program activities to meet their personal needs and goals.

Several long-term programs also encouraged teachers to immediately use newly gained skills and knowledge directly in their classrooms at the same time as the oTPD program, thereby engaging in long-term cycles of PD activity and classroom teaching. For instance, both Hjalmarson (2017) and Zhang et al. (2017) had teachers repeatedly implement lesson plans that were developed in PD and return to the program after each implementation to reflect with peers and post outcome reports on personal blogs or community message boards. Similarly, Sherman, Beyers, and Rapp (2008) solicited reports from teachers' daily teaching as they participated in the oTPD. With this information, they provided custom, on-demand information to teachers as they needed based on what teachers were experiencing in their classrooms as they tried out new approaches from the PD. The ability to simultaneously to participate in PD try out ideas in actual classrooms is best suited for longer-duration ongoing oTPD programs, as teachers would have more opportunities to engage with material encountered in the PD with their students as they participate in oTPD parallel to their own classroom teaching (Owston, Sinclair, & Wideman, 2008). To this end, oTPD affords opportunities for authentic learning and connectivity, as web-based platforms afford asynchronous participation in oTPD activities parallel to classroom teaching.

Finally, 18 studies failed to mention the duration of their programs. Because of the significant differences in timeframes that can be realized with oTPD, the duration of programs should be included in future reports to allow scholars to rigorously compare intervention designs and their effects.

Considered as a group, the studies of the previous decade illustrate a significant commitment by designers to provide long-term oTPD programs to teachers. The signature affordance of oTPD is that it can provide ongoing and regularly active PD experiences for teachers through connection via the Web. Ongoing, just-in-time, and self-paced flexible PD is possible with these technologies in more ways that years past. Toward this goal, the field has substantially expanded the offerings of long-term PD programs to teachers, meeting a critical need expressed by scholars in the field.

2.3.2 Research Designs for Studying oTPD between 2007-2017

oTPD programs have been formally researched in multiple ways by scholars in recent years. The foci and methodologies employed by scholars from 2007 to 2017 presented evidence about oTPD from many different angles. However, the research designs observed in this review have only barely addressed the challenges issued by Wayne et al. (2008) and Hochberg and

Desimone (2010) to account for variation in participation and experience within each design feature of an oTPD program. In addition, the research foci, questions, and methods employed by researchers were largely focused on how participants interacted with programs, with less emphasis was placed on investigating oTPD program effectiveness to address the field's need for understanding what makes an efficacious PD program (Dede et al., 2009; Desimone, 2009; Lawless & Pellegrino, 2007). The following paragraphs discuss the trends that were observed in the research design and foci of the past decade of oTPD studies, with an emphasis on areas of improved methodological robustness that have been recently promoted by members of the PD research community, as well as highlighting areas that have not been as well developed in recent years.

2.3.2.1 Accounting for Experience, Participation, and Exposure to PD

As online and other digital learning environments are less structured and allow flexibility in the timing of work, the multiple types and levels of teachers' participation and interaction with design features serve as an important indicator of the degree to which an oTPD intervention is used. To this end, oTPD programs from the previous decade largely acknowledged that variation of participant experiences exists within the multiple design features that are often implemented in a program. However, most studies did not formally account for these differences within the implemented research designs through the inclusion of varied levels and types of participation in analyses. Table IV illustrates a rank ordering of the degree to which experience and participation within oTPD programs were examined by researchers.

TABLE IV

LEVEL OF ACCOUNTING FOR EXPERIENCE AND PARTICIPATION WITH OTPD FEATURES

Level	No. Studies	Description
1. Systematic measurement of participation	2	Researchers systematically defined and measured participation or level of experience; used these measures in the formal study
2. Systematic description of participant experience	14	Researchers systematically described in detail the variations in experience of participants, categorized and identified themes of different experiences with oTPD features and activities.
3. Acknowledgement of variation in experience	23	Researchers acknowledged that differences in experience or participation existed, but did not investigate these as part of the formal study.
4. No account for variation in participation, or use of binary measures	15	Researchers did not account for differences in participation or experience. Or, researchers assigned a binary condition to participants, which considered all participants equally.

Systematic measurement of participation. During the previous decade, only two studies systematically measured teachers' participation or interaction with PD features and subsequently used this data to account for teacher change as a possible function of differences in experience with a PD intervention and their features. In the first of these studies, Rolando et al. (2014) developed an inventory of the 10 different ways that teachers could participate in their virtual learning community. To create the inventory, they identified and categorized the qualitative differences in interaction that the oTPD environment afforded, such as didactic communication, personal study, and socialization. From these 10 interaction types, Rolando and colleagues tallied the frequency by which teachers engaged in each of the interaction types and compared these interactions to teacher classroom behaviors, finding little connection between the two. In founding their study, Rolando and colleagues recognized that it was important to first clearly define the types of interactions that can occur in the oTPD to enable measurement of teachers' experiences with each of the features. Similarly, Fishman et al. (2013) presented a traditional experimental field trial to investigate oTPD efficacy in which participants were assigned to a treatment or control condition denoting participation in the oTPD program. However, they also accounted for variations in the amount of time spent by participants in the various online components as a part of their experiment. Although they found no significant differences based on the amount of time spent with oTPD features to teacher outcomes in the oTPD condition, they recognized the importance of accounting for variation in experiences among participants. They also held that it was a possibility that differences in time spent could influence participants' experiences, and as a result, experiences should not be assumed to be equal in an online program. Because of this, the level of exposure that participants had with the PD intervention likely represents a necessary mediating variable that likely has value in efficacy studies.

Studies with systematic description of participant experience. In a less formalized, but likewise systematic approach to accounting for the amount and type of interactions with oTPD features, authors of 14 studies presented descriptive narratives and process-based analyses that addressed the different ways that participants interacted with oTPD features. Descriptions in this category typically relied on both quantitative and qualitative data, and were most frequently coupled with investigations of PD learning processes and technical evaluations instead of program efficacy. Although this approach does not examine variation in participation in the context of program efficacy, such process-based analyses are equally important to the field for identifying the types of interaction opportunities within common oTPD features (Beach, 2017;

Owen, 2017; Prestridge, 2010). Descriptions offered by scholars included analyses of the ways participants posted in online communities or message boards (Chai & Tan, 2009; El-Hani & Greca, 2013; Zhang, Liu, & Wang, 2017; Zhang et al., 2017), the different procedures by which mentors and mentees interacted with multiple communications media (Owen, 2017), and variations in the different types of personal writings and reflections by participants in conjunction with how they used other PD features (Unwin, 2015).

Detailed descriptions commonly offered with this approach are also important to the field for advancing theoretical understandings of professional learning processes. As an illustration, Wang et al. (2014) qualitatively observed and documented how teachers used oTPD features to identify factors that could be influencing teachers' high or low levels of participation, such as level of technology skills, time availability, or lack of access to technology. Descriptions of participant experiences and participation in PD can continue to compliment efficacy studies as researchers can detail the different ways and qualities by which participants interact with oTPD features, which in turn can be used to define measures that account for exposure to and experience with PD features (Hull & Saxon, 2009; Rolando et al., 2014). As such, this approach is necessary, but not sufficient for answering all of the questions regarding the degree to which oTPD interventions and their constituent features are used and with what effects (Wayne et al., 2008). However, when possible, rich descriptions of the varied ways in which participants interact in a PD system would complement well any formal measures and accounting for such interaction in studies.

Acknowledgement of variation in participation, but not accounted for in study. In comparison to the above-mentioned categories, many studies in this review did not systematically operationalize or procedurally describe how and to what degree participants interact within the oTPD. However, this did not mean variation in participation was completely absent from these studies. 23 authors informally discussed the variation in the oTPD experiences of teachers. These distinguishing characteristics of this category compared to that of those that used systematic description above was that the present variation was only unexpectedly or anecdotally observed during an investigation into some other aspect of the oTPD, and not a part of the official research design. In one noteworthy example, researchers' use of commonly available online server logs and clickstream data often plainly revealed that participants in their oTPD programs did not use features in the same way. In this way, Bate, Phalen, and Moran (2016) reviewed Google Analytics logs from their oTPD website as a part of their main research question unrelated to participation. As a result, they also noticed in parallel that participants accessed videos and other information in non-uniform ways with enough variation that even a casual observation of the website analytics data indicated substantial differences. In another example, although it was not a focus of their formal analysis of how teachers performed connectivist practices in their classroom, Graham and Fredenberg (2015) noticed clear differences in how participants interacted during oTPD. In response, they suggested that participation differences were likely related the behaviors that they were investigating and would make for an interesting area of examination, which was noted by other scholars who also informally used server log data to observe participant interaction differences (e.g., Kale, Brush, & Saye, 2009; Seraphin et al., 2013; Walker et al., 2012).

In a similar trend, scholars often casually observed that although not part of their main analysis, the frequency and content of teachers' written works during oTPD often differed among participants. (Hanuscin et al., 2014). For example, Chen, Jang, and Chen (2015) noted multiple differences in the experiences teachers had during oTPD, as reported in teachers' reflective journals during the program. To this end, Chen and colleagues suggested that these differences merit additional study. Often, different teachers chose to share more or less in the social or creative components of the PD, which was echoed by multiple other scholars (Hou, Sung, & Chang, 2009; Liu, 2012; Polly et al., 2016). Although these indirect observations of variation may indeed lead to analyses in and of themselves, the examples presented above were not used in the formal analyses in the studies in which they were reported. In other words, they were offered in a way that supplemented the narrative of the design and research report, but were not directly used in the research design of the study. The studies in this category highlight examples of unexpected trends in variations in participation that occur within online environments that researchers encountered during their original analyses, but which merit some discussion in research articles.

Studies without mention of or accounting for variation in participation, or used binary measures. Finally, in contrast to the above-mentioned studies, 15 studies did not account for the possibility of variations in teacher participation or interaction with multiple PD features. Studies in this category either made no mention of variation in participation or interaction (e.g., Cavanaugh & Dawson, 2010; Ostashewski et al., 2011; Shea, Mouza, & Drewes, 2016), or treated participation within the formal analysis uniformly, with each participant's experience being assumed as the same. Most often, studies in this category generally held teachers as equal participants, regardless of variation in their levels of participation or different patterns of interactions (Kellogg, Booth, & Oliver, 2014; Martin et al., 2016; Qasem & Viswanathappa, 2016; Sherman, 2008). It is certainly simpler to implement studies with such an "everyone has similar PD experiences" assumption, as it can be held that there was at least a basic uniformity among experiences and observed and that any observed changes could be attributed to a general

PD experience offered to all participants (Francis-Poscente & Jacobsen, 2013). However, such an assumption withholds useful participant interaction data from any analysis that could allow researchers to identify which elements work or didn't work as expected.

Uniform participation was indeed formally included in some studies but did not qualify for an accounting of variation in teacher participation during oTPD. Such measurement was typically captured in a binary way through experimental treatment and control conditions. An example of such a binary participation measurement assigned a score of 0 to participants representing a control condition of receiving "no PD" and a 1 to those representing "received PD," which exemplifies traditional field trial and experimental approaches to examining PD efficacy. As a result, these studies did not account for interactions that occurred within the "black box" of a PD's inner workings and features (Wayne et al., 2008). The level of participation within this conception is held uniform by design across participants regardless of the combination of features that appear within an oTPD program and the various combinations of patterns in which participants can use them (e.g., Ho et al., 2016; Malanson et al., 2014; Masters et al., 2010). As a result, the assumption of uniform participation makes it difficult for readers of research know the degree to which participants' experiences differed within oTPD interventions and the degree to which the intervention and its features were used.

The discussion above highlights a significant gap in oTPD literature that accounts for the potentially infinite ways that teachers can participate in and experience PD that use online interactive tools. As an intervention realistically has no effect unless participants use it, it is important to qualitatively and quantitatively assess how participants use these interventions. Because the most frequently cited affordance of online technologies for PD is personalization and flexibility, researchers need to emphasize the measurement of how interventions are used in order to examine if differences in experiences or exposure to PD elements have effects on outcome achievement (Dede et al., 2009; Wayne et al., 2008).

2.3.2.2 Foci of oTPD Research and Methods Used

The research questions appearing in oTPD publications from the previous decade have generally aligned well with the previously observed categories of research foci by Dede et al. (2009) on the contents of oTPD research from before 2008. The observed research questions within these foci also closely align with the "methodology" dimension of oTPD studies that was observed in the review by Lawless and Pellegrino (2007). In this section, the reviewed studies were categorized by research foci and research question using a four-category scheme modified from those observed by both the studies from Dede and colleagues and Lawless and Pellegrino.

TABLE V

RESEARCH FOCI OF OTPD STUDIES AND METHODS USED TO INVESTIGATE RESEARCH QUESTIONS, 2007-2017

Research Foci	No. of Studies	Description	Methods Commonly Used
Descriptive Accounts	26	Studies that describe, in detail, oTPD interventions; General program evaluations.	Descriptive evaluation reports Case study
Program Effectiveness	14	Studies that investigate whether program goals were met, based on measured outcomes.	Randomized experiments Quasi-experiments Observational quantitative comparison (single-group)
Technical Feature Analysis	13	Technology-centric studies that examine how and with what effect a specific technical feature operated in an oTPD.	Observational quantitative comparison (single-group) Case study
Processes of Professional Learning	17	Investigation of professional development processes and interactions within oTPD interventions.	Case study Social network analysis Basic qualitative study Mixed methods thematic analysis

Note: categories are not mutually exclusive, as studies could have multiple foci or research questions

These four categories account for multiple trends that have appeared in studies regarding advancements in web-based technologies over the last decade and calls by the research community toward understanding "what works and why" in PD (Lawless & Pellegrino, 2007). These research foci include (1) providing descriptive accounts, (2) demonstrating program effectiveness, (3) analysis of technical features, and (4) analysis of processes of professional learning. In addition, multiple studies had more than one research focus, so some studies appeared in more than one foci category. Table V summarizes these four categories of research foci, as well as the frequency of studies using each focus. Included in the table are the research methods that were commonly used by researchers to investigate oTPD programs in each category.

Descriptive accounts. In the first category, the authors of 26 studies focused on providing general program-level descriptions and evaluations of the oTPD or its participants. To enrich these descriptions, authors often used quantitative measures of design features, program outcomes, or participant interactions to supplement their descriptions. Within this category, researchers often reported descriptions of program design, researchers' perceptions of how programs achieved goals, participants' general perceptions of programs, and whether programs met the designers' expectations. An illustrative example of this approach is in the descriptive account of an oTPD performed by Owston, Sinclair, and Wideman (2008) in which they described and reflected on how their program was conducted after one implementation. As a result of this evaluation, they found that teachers generally had high levels of satisfaction after the program, as well as found the program's hybrid learning format valuable. Using a combination of server clickstream logs and participant writing, Owston and colleagues also explored whether their expectations regarding how the PD was used were met, finding that participation was lower than expected. In another example, Vu et al., (2014) provided a rich description of their PD program by using surveys and activity logs to narrate how their program both met and fell short of expectations for both the designers and participants.

Another observed trend in descriptive-type evaluations of oTPD was the study of participant satisfaction and participants' perceived value from programs. This trend is certainly not new to the field, as it was also commonly observed by both Lawless and Pellegrino (2007) and Dede et al. (2009) in their previous reviews of PD programs. To this point, both Lawless and Pellegrino and Dede and colleagues suggested that the practice of basic evaluation was no longer advancing the PD/oTPD field in a productive way. Although such studies are easy to complete through a post-participation questionnaire or survey, they little to demonstrate how and with what effects participants engage in oTPD. In the studies in this review, satisfaction-type studies were largely completed with qualitative or anecdotal reporting of survey data from participants, or asked participants to self-report their level of learning only at the end of the program, such as with only a post-program survey (Duncan-Howell, 2010; Edinger, 2017; Salmon et al., 2015).

Although multiple authors of studies indeed provided evaluatory reports and overviews of their programs, they also often investigated additional research questions and had multiple categories of research foci. In fact, of the 26 programs that performed program evaluations, only a handful *only* included basic evaluations or surface-level analyses of programs (8 studies). Instead, oTPD publications in this category investigated most often other more robust research questions and were supplemented by program-level evaluations. Therefore, the field appears to have shifted from predominantly discussing the satisfaction of participants or simply describing oTPD programs to performing more in-depth investigations on the processes and effects of oTPD programs. This shift has been promoted by multiple reviewers and scholars in the field over the previous two decades as necessary for a more robust understanding of PD theory and efficacious design (Dede et al., 2009; Desimone, 2009; Hochberg & Desimone, 2010; Lawless & Pellegrino, 2007; Wayne et al., 2008). To this end, program-level evaluations remain useful toward adding context and design information within publications, but should not be the sole focus of investigation.

Program effectiveness. To demonstrate program effectiveness, 14 studies quantitatively analyzed oTPD program efficacy with varying methodologies. Over the past decade, scholars performed oTPD efficacy studies by either investigating whether outcome measures that reflect program goals were higher at the conclusion of the program than at the start (e.g., pre-post measures), or by examining whether the PD intervention as an independent variable had any statistical effect on outcome variables. To accomplish this, two methodological approaches were typically used within the studies in this category. First, some studies had an experimental or quasi-experimental structure, with the PD intervention being a treatment condition in comparison to some other control condition in which teachers did not participate in PD and participants were randomly assigned treatment conditions. Second, efficacy was also examined through observational comparison, in which a single treatment group was observed for changes in measures based on the goals of the PD program.

First, some researchers used experimental procedures to examine program efficacy on dependent outcome variables. Fishman et al. (2013) and Masters et al (2010) are the only two authors in this review that utilized full randomized experimental approaches in their studies. In the most illustrative case, Fishman and colleagues completed the most traditional-style randomized field trial of the studies in this review by examining randomly assigned groups of teachers who had either face-to-face or online PD. According to Fishman et al., only the location of the PD was different between conditions -- teachers were provided the same content and similar interactions in both types of PD. They concluded that they could observe no distinguishable difference between online of face-to-face conditions, if PD content and activities are held constant. However, the study experienced some major criticism from Moon et al. (2014) toward its findings that there was no difference between face-to-face and online PD. At the heart of Moon and colleagues' response to Fishman and his co-authors was whether the face-to-face and online interactions and features that were held "constant" in the experiment were indeed providing the same experiences as they were assumed to be. Instead, it was argued by Moon et al. that participants could experience these PD conditions in unique ways within both the face-to-face and online approaches based on their prior experiences and the affordances of the specific PD design. In other words, the interactions in face-to-face and online PD may not be equal, even if participants do the same *type* of activity. To this end, Moon et al. encouraged the research community to consider if whether comparisons between the two conditions could be made with a high degree of validity.

These arguments are similar to those made by Kozma (1991) in earlier years of educational technology research. In a series of famous debates about "media effects" that played out over series of published articles over close to a decade, Kozma suggested that each media type or content delivery mechanism used in a learning environment likely affords unique types of interactions, understandings, and opportunities to use information (Clark, 1991; Kozma, 1994; Morrison, 1994). On the other side of the debate, Clark (1983) claimed that media choices and delivery mechanisms in digital learning environments were "mere vehicles," and it was only a matter of finding the right combination or amount of media to gain understanding or achieve designs that would yield similar results in different learning environments. Although the arguments have become more nuanced between these two groups, the similar type of claims about media between Fishman et al. (2013) and Moon et al. (2014) reveals that theoretical assumptions about media use and the "delivery" of PD programs remain to be an important area of debate in the field (and, as a result, demonstrably lacking a consensus). However, despite the modern challenges with experimental approaches in PD, the study by Fishman et al. demonstrates a worthwhile attempt to demonstrate program efficacy in a way that was appropriate based on its contexts and did not put participants in the control condition in a disadvantaged position.

Unlike the study discussed above by Fishman et al. (2013), random assignment between experimental conditions is often difficult or impossible to achieve based on the mission of providing PD to any teacher wishing to participate. Quasi-experimental approaches were used by five scholars to address challenges with participant selection and condition randomization in complex oTPD environments (Malancon et al., 2014; Qasem & Viswanathappa, 2016). One illustrative example of an oTPD efficacy quasi-experiment is by Ho and colleagues (2016), who sorted participants into experimental condition groups based on their demographics to achieve balance among participant groups and examined teachers' knowledge, self-efficacy, and satisfaction as a result of participating in the program. Similarly, Walker et al., (2012) conducted a quasi-experiment to examine teachers' knowledge, skills, and technology integration practices based on the science content covered in the PD. They used a generalized estimating equation model to also examine the subsequent effect of PD on students, in which the examination of student effects was rare among studies in this review. Although the selection of participants was not truly random with these studies in comparison to the full-experimental method described above, they all examined statistical differences in quantitative outcome variables between two or more groups of participants that were selected by the researchers with some degree of rigor to address challenges in selecting participants at random for a voluntary, informal oTPD program. In a second approach to efficacy methodology, quantitative single group analyses were performed by scholars, which are often called *observational studies* by experimental methodologists (Shadish, Cook, & Campbell, 2002; Wayne et al., 2008). This approach was used in 7 studies to examine program effectiveness. It was typically accomplished using a pre-post measurements of variables of interest and use of basic statistical methods, such as t-tests or ANOVA models, or if multiple independent variables are used, linear regression and ANCOVA models. An example that collectively illustrates these seven studies is that of Moore et al. (2016), who used basic statistical tests to examine differences between pre and post assessments of participants' frequency of use, feeling of preparation, content knowledge, and perceptions of alignment of the PD to goals. There was only one subject group in this study as the PD program was offered to all participants without an alternative program that was offered to serve as a control. With oTPD programs, there is usually no control or alternative subject group that is commonly present in an experimental study, as programs are more focused on providing high quality professional development to their teachers and investigating new approaches to PD rather than conducting a multi-group experiment. Although the inner workings of the PD were treated as a "black box" and obscured from the research model, Moore and associates observed significant positive changes in teachers' preparedness and knowledge after participating in the PD, while not observing any change in teachers' perceptions of relevance of the PD or their own level of empowerment to enact the material from the PD.

The observational-type studies examined the effectiveness of programs based on differences within the treatment group alone to determine if goals were met. Although they are not defined as experiments and are thus limited in their ability to describe causal relationships, observational approaches nonetheless provide opportunities researchers who are unable to complete experimental trials with their PD programs and should not be discounted. When designed well, observational approaches offer tools that provide evidence to the oTPD field on efficacy of individual programs and features, as well as insights into factors that might influence the achievement of outcomes (Wayne et al., 2008).

A more novel third approach also was observed in this review. In an excellent example of simultaneously investigating both theory-based processes and efficacy in oTPD, Wang et al.

(2014) conducted a design-based research (DBR) study of their program. As the only example of DBR observed in this review, the study examined changes through multiple iterations and changes of the program design and documented changes in both qualitative processes and quantitative outcome measures. Working with a group of 25 teachers, Wang and colleagues organized part of their study to include four quasi-experimental studies that measured and compared multiple groups' changes in teacher practice, knowledge, and student outcomes over four design iterations. However, despite qualitatively describing differences in participant experiences as part of their complementary investigation on processes of learning, neither Wang et al., nor any other author of efficacy studies in this review included independent variables of variations to participation or interaction with PD features in their designs. This type of measure has been suggested by Wayne et al. (2008) to formally account for dosage or exposure to PD interventions in statistical efficacy research models and increase rigor in experimental approaches. However, Wang and colleagues addressed the challenge of simultaneously focusing on iterative design and efficacy using DBR in oTPD, which was specifically called for by Dede et al. (2009) in their previous review of the field's literature.

However, at least two observational-type studies in this review were conducted with less levels of rigor than has been encouraged the oTPD community, including the use of single time points to argue for program effectiveness. The study by Edinger (2017) is a useful example to illustrate the challenges of rigor that still appear within the field's peer-reviewed research. In the study, Edinger departed from the field's conventional pre-post design to document changes in teachers and examined PD efficacy from a single group at a single time point, despite this being a less robust approach to make claims about observable changes in teacher skills and knowledge. At the close of the PD program, Edinger collected self-reported data from teachers on their perceived behavioral and knowledge changes as a result of participating in the PD and examined differences based on participant demographics. With only a single time point and few (if any) independent variables related to the intervention to account for intervening influences, it is difficult for the field to infer any change or effect of the PD program on teachers' knowledge or practices.

Although randomized field trials are often regarded as the "gold standard" of behavioral research, the use of observational-type analyses for efficacy are just as important in the field of oTPD. Randomized experimental analyses are indeed more difficult to conduct in authentic, informal oTPD settings because the participants themselves are usually volunteers and, as such, participants self-select themselves by default from the outset (Borko, 2004). As a result, it may be impossible to achieve large-scale, full-program true randomized experiments within the oTPD field, making observational-type studies useful toward advancing research in the field. In addition, PD interventions in general are aimed to help anyone that desires improvement, making the possibility of being sorted into a control condition undesirable as the participant would not receive the designed research intervention. Observational-type studies with a single treatment group have an increased risk of selection bias, which is a concern with conducting experimental research from which causal claims about theory and interventions are made. Despite this limitation, observational-type efficacy studies still provide useful analytical approaches that may only be available to single-group program design (Desimone, 2009; Hochberg & Desimone, 2010; Wayne et al., 2008). In other words, observational single-group efficacy studies are likely better than nothing, if conducted in a rigorous way.

Despite the methodological challenges associated with performing efficacy research, additional care by researchers can be made to improve studies' methodologies to be as robust as possible to measure efficacy. Both experimental and observational-type methods can be used where appropriate based on program structure and the type of participants interacting with the program, and thoughtfully interpreting the data with consideration for whichever method was used in order to make claims about program efficacy (Borko, 2004; Dede et al., 2009; Wayne et al., 2008). In the case of observational-type methods, certain procedures can be integrated to reduce experimental error and bias during participant selection and the conduct of the study. These include estimating treatment effects with measures of known factors that correlate with PD participation and student outcomes (e.g., having a degree or advanced training in the subject), or the use of information about the degree to which teachers generally join or don't join PD programs to balance the pool of subjects (Wayne et al., 2008). In addition, as mentioned in the section above, the use of participation or interaction data from within the PD would likely be valuable variables for both experimental and observational-type efficacy studies for investigating the dosage or exposure to the PD intervention and its various features, and increasing the robustness for evidence-based arguments of efficacy, either through experimental effects or observational-type changes (DeBoer et al., 2014; Hochberg & Desimone; Wayne et al., 2008). In the case of oTPD, such data are readily available in the form of server log files, user clickstreams, and other learning analytics that can be automatically generated as participants interact with digital systems.

Technical feature analysis. Similar to program efficacy, this category was first identified by Dede et al. (2009) as substantially different enough of a research trend to merit its own category. Indeed, this category remained relevant for the most recent decade of oTPD research. 13 programs separately examined procedures of how and with what effect participants used specific features within an oTPD program. Described another way, this category takes a feature-centric approach by essentially asking the question: "how did this specific feature perform." The features in this category are also typically novel to the field or exhibit new functionalities that are being explored in PD contexts. This could include investigations of how participants use the feature or how effective the feature was at achieving goals. Examples of singular features examined at this level include message boards or forums (Kellogg, Booth, and Oliver, 2014; Seraphin et al., 2013; Sherman, Beyers, & Rapp, 2008), the use of technologies for the classroom (Martin et al., 2016), teacher portfolios or journals (Seraphin et al., 2013), badges and achievements (Gamrat et al., 2014), and use of instructional modules (Wang et al., 2014). Case studies of specific feature implementations were utilized by four scholars to examine how and to what end features were used. In one example, to examine how the interactive communications features were used within their program, Chen, Jang, and Chen (2015) performed an interpretive case study. Procedurally, the discourse characteristics of teachers were openly coded by Chen and colleagues from teachers' writings from the communications tool and, from this single case of program implementation, categories of discourse that occur within the oTPD were identified by the study's authors. Taking a slightly different approach, Gamrat et al. (2014) examined the use of digital badges in an oTPD program by comparing and contrasting teachers' experiences within a collective case study. Although it examined only one implementation of a badging program, their case study was termed *collective* as the researchers simultaneously considered the experiences of 8 teachers within the single implementation. Through continual comparison, Gamrat et al. identified themes of activities that teachers do with the badging system through a thematic analysis of teacher's written data that reflects their experiences with the badging system.

In addition to case studies, six scholars used other qualitative approaches to investigate features in programs. Scholars performed more general or "basic" qualitative studies that were guided by the systematic and iterative thematic categorization of data sources as interpreted by researchers to investigate feature use (Merriam, 2009). A typical example of this appears in Unwin's (2015) study on the process of how digitally moderated discussions influence teacher inquiry. To investigate how people use discussion tools toward activities of inquiry, Unwin examined and categorized through qualitative coding a number of written works by and interviews with teachers. Each new category that was observed was compared with existing categories and defined in detail. The iterative analysis of these data allowed Unwin to interpret a number of categories of actions that influence teachers' inquiry behaviors, ultimately leading to new understandings toward how and with what ways the discussion modules in the course were used to achieve these goals. Similar interpretive qualitative approaches also appear in the work by Francis-Poscente and Jacobsen (2013), Liu (2012) and Prestridge (2010). Alongside the studies that used only qualitatively derived data, Bates, Phalen, and Moran (2016) sought to investigate the use of video in their program by employing a mixed-methods approach. With a goal of defining learning processes and factors that influence use, they used both quantitative learning analytics collected by the online PD system as well as qualitatively categorized video ratings and personal reviews of videos to understand important aspects of video in their program.

This group of studies partially addresses the need to describe and measure the use of multiple design features of oTPD programs that has been prescribed by Wayne et al. (2008), Hochberg and Desimone (2010), and Borko (2004). However, these studies are distinguished from the rest as they do not account for whether the overall program met desired goals, nor describe *all features* within a program in detail. Instead, studies following this trend typically described a single feature or technology in detail and rarely described multiple features being used in combination. This approach then is useful toward investigating the use of specific technologies or features in oTPD programs, but is generally not sufficient to respond to questions about what *programs* work best toward achieving goals and subsequently promoting investments in programs that work.

Processes of professional learning. Another popular focus within studies from the previous decade were those that sought to advance theories of professional learning by either identifying and tracing processes and interactions in professional learning, or investigating external factors that influence individual professional learning. 17 studies adopted research questions and methods that align with this focus.

Of these studies, four scholars indicated that they used case studies of specific oTPD implementations to describe and unpack the learning activities of teachers (e.g., with procedures similar to that described by Yin, 2009). By design, case studies do not have to be purely a qualitative endeavor, which is useful in oTPD environments that can generate significant amounts of quantitative interaction data. In such a case, Kellogg, Booth, and Oliver (2014) performed a mixed-method case study of an oTPD implementation to examine peer interaction structure and patterns. By looking at a combination of social network analysis, learning analytics, and a qualitative analysis of participants' posts in forums, Kellogg and colleagues identified and triangulated the various structures that were present among participants' interactions with each other in the context of a single PD program. Using case studies in another way, Chai and Tan (2009) examined the discussion forums of an oTPD called The Knowledge Forum. Within the context of this PD, they adopted a mixed-methods approach for their case study by using a qualitative interaction analysis model and social network analysis to examine teachers' text posts to identify the different ways that people interact in a social PD environment and factors that influence discussion (such as intent or purpose of conversations). Their analysis also included the use of quantitative participation data to contextualize variations in interaction between participants. Although the reviewed process-focused papers that used case studies do not address program effectiveness, these reports can be useful to designers who wish to better understand the types of interactions that might be expected within certain oTPD contexts.

The remainder of the studies in this category used other qualitative or mixed methods approaches to investigate the processes of learning within PD. A portion of these studies were collectively focused on understanding how professionals collaboratively build knowledge. For instance, Zhang et al. (2017) performed both a structured content analysis on written posts by teachers in the oTPD and lag analysis using behavioral learning analytics to describe the processes of social learning and collaboration that teachers use within an oTPD program. Using a different approach toward a similar question, Albers, Pace, and Odo (2016) completed what they termed an *interpretivist qualitative study* to describe the processes of knowledge construction by teachers through negotiation and reflection. In addition to the qualitative portion of their study, Albers and colleagues also used learning analytics from online interactions to support their qualitative findings. Other studies in this category asked a similar set of research questions, but instead investigated social phenomena at a different grain size than those projects listed above. These studies were more broadly interested in the composition of PD communities and the primary ways that teachers performed work within their communities of practice (Dalgarno & Colgan, 2007; El-Hani & Greca, 2013).

Similar to social knowledge construction, another small group of studies in this category were focused on how participants found and used information within an oTPD. In an illustrative example, Berger, Eyelon, and Bagno (2008) performed a descriptive content analysis to identify how use of the oTPD environment how themes of teachers' inquiry and practice in the oTPD over 9 months were continually connected, or alternatively were broken up into smaller thematic segments of information and online community use in the oTPD system. To generate themes of learning activities by both duration and continuity of patterns of reasoning, they utilized a grounded theory approach in which messages posted by teachers in the environment, web log data, and transcripts from meetings with teachers were continually analyzed until themes emerged. Other methods used to investigate processes of informational use and subsequent learning include basic thematic qualitative analysis (Unwin, 2015), an inductive analysis of the system and social interactions within online PD modules (Polly et al., 2016), and analysis of similarities and differences between processes using qualitative descriptions and tracking of teachers' clickstreams, screen captures, and think aloud dialogue within an oTPD system (Beach, 2017).

It is also important to note a new trend within this body of oTPD work: process-based studies and descriptions in this category often did not rely solely on qualitative analyses. Indeed, many qualitative approaches that have been common in the education literature were present in the reviewed studies. However, multiple oTPD papers in this review also used quantitative learning analytics data from online environments to complement qualitative analyses to some degree (e.g., Albers, Pace, & Odo, 2016; Hou, Sung, & Chang, 2009; Renninger, Cai, Lewis, Adams, & Ernst, 2011; Zhang et al., 2017). This trend toward the use of both descriptive and predictive quantitative analytics in process-based studies reflects an added benefit that researchers gain from providing oTPD opportunities and the ease of collecting interaction data online. As a result, clear instances and sequences of interactions can be captured in the data, and qualitative claims can be better evidenced through triangulation of sources than when relying on qualitative analysis alone.

2.3.3 Units of Analysis in oTPD Studies between 2007-2017

Lawless and Pellegrino (2007) identified that technology-based PD programs before 2007 featured research questions and variables of interest that reflected three general units or groups of analysis: teacher-level, program-level, and student-level. Each of these units of analysis reflect different layers in the typical professional development chain of theory, or logic model, with PD programs typically intended to influence more immediate proximal changes in teachers, which subsequently influence more distal changes in students through interaction with their teachers who participated in PD (Wayne et al., 2008). The studies presently reviewed largely aligned with the same categories of units of analysis observed by Lawless and Pellegrino. Therefore, in this section, studies were reviewed based on the three levels of subjects that were typically investigated: teachers, students, and whole programs. Within each unit of analysis, additional sub-units or grain sizes were also observed, which are also further described in this section. Table VI provides a summary of these three categories and their included studies.

TABLE VI

UNITS OF ANALYSIS OBSERVED IN STUDIES FROM 2007 TO 2017

Unit of Analysis	No. of Studies
Teacher-level	53
Program-level	23
Student-level	6

Although at least some studies appeared in each of the three categories, the number of studies appearing in the teacher-level category was substantially larger than that of the other two categories. This same trend was observed in the prior findings by Lawless and Pellegrino and by Dede et al. (2009), indicating that little change has been made in this area toward including program and student-level units of analysis in oTPD research. This includes few findings observed in this review concerning the scaling of PD programs (a program-level unit of analysis) or changes in students' learning outcomes as a result of their teachers participating in PD (a student-level unit of analysis).

The concepts of research foci and units of analysis in this review are similar, but they differ in an important way. With the research foci discussed in Section 3.2, studies were categorized by both the type of research question asked and the goal of the study. In considering units of analysis in this section, studies are categorized by the level of analysis or grain size of data that are analyzed. This section is concerned with the subjects of the study, or who or what is being studied. Studies in this review were also eligible to be included in multiple categories if they demonstrated multiple units of analysis. For example, a study with a research focus of program effectiveness can simultaneously investigate multiple units of analysis, such as teachers and their interactions and outcomes, as well as student outcomes.

2.3.3.1 Teacher-Level

As oTPD programs are designed for teachers, they are the closest to such interventions. could be readily expected then that research questions and findings in oTPD studies from the previous decade mostly concerned with teachers, with 53 studies having teacher-level units of analysis. These studies examined grain sizes of both individual teachers and teacher groups. Concepts of interest in these studies included teacher development of knowledge, skills, beliefs, practices, implementation of pedagogy, dispositions, and processes of learning within PD.

One subset of the teacher-level analysis category included studies that investigated teachers' development of knowledge or beliefs regarding content, technology, and teaching in the disciplines. Particularly common among this subset of studies were examinations of increases in teachers' content knowledge related to specific disciplinary topics in oTPD programs (e.g., Fishman et al. 2013; Owston, Sinclair, & Wideman, 2008; Sherman et al., 2008; Walker et al., 2012). For example, Masters and colleagues (2010) examined teacher gains in English language arts content knowledge from an oTPD, which was compared to teachers who participated in an in-person PD. Using a pre-post experimental design, they found that both PD groups scored higher on knowledge and confidence in language arts content, but those that participated in oTPD exhibited higher effect sizes on increased levels of knowledge and confidence than that of the control group. Additionally, some studies investigated teachers' development in knowledge about and attitudes toward new technologies to be used in the classroom (e.g., Ching & Hursh, 2014; Renninger et al., 2011; Walker et al., 2012). Although these examples are just a few of the many in this review that explored elements of teacher knowledge and attitudes, the examples also demonstrate that multiple simultaneous layers of psychological phenomena continue to be investigated in relation to oTPD programs, making it a popular area of research during the previous decade.

Another subset of teacher-level analysis can be characterized by investigations into changes in teacher practices or use of pedagogical approaches. Within this subset, it was common for studies to investigate how teachers' classroom teaching was influenced by participating in an oTPD program. Examples of this include the measurement and description of how teachers use new technologies for teaching purposes (Moore et al. 2016; Walker et al., 2012) and how teachers prepared for everyday interaction with students (Shea, Mouza, & Drewes, 2016; Unwin, 2015). Some studies also investigated how and to what degree teachers perform certain teaching strategies as a result of oTPD participation, including strategies to promote student creativity (Al-Balushi & Al-Abdali, 2015), use of connectivist teaching practices (Graham & Fredenberg, 2015), and student-centered pedagogical approaches (Martin et al., 2016). Also in the category of teacher-level practices were studies that questioned how and to what degree teachers implemented new curricula or pedagogies with a high level of fidelity. For instance, Fishman et al. (2013) specifically intended their oTPD to support teachers' high fidelity of implementation of a novel curriculum. In an experiment between oTPD and traditional face-to-face programs, they found that both groups exhibited high levels of fidelity and knowledge gains, but no differences were observed between the oTPD and face-to-face teacher groups. Although this is only one example, the findings by Fishman and colleagues exemplify the type of evidence that is useful to the field for determining the appropriate contexts in which to employ oTPD programs to meet goals for improving teacher practice and promote sound PD investments (Fishman et al., 2013; Hochberg & Desimone, 2010; Moon et al., 2014).

A third subset of studies was concerned with examining teachers' interactions in oTPD environments and the processes that teachers employed for learning within oTPD programs. However, it is appropriate in this discussion on units of analysis to highlight that studies in this category examined teachers' learning processes at various "grain sizes." To this end, the most common grain size observed in this review was that of the single teacher, with which studies contrasted participants with their peers to gain insights about professional learning processes. For this subset of studies, data sources for investigating teachers' interactions were typically generated from teacher work artifacts in oTPD environments, such as writing tasks or online discussion forums (e.g., Ching & Hursh, 2014; Duncan-Howell, 2010; Kale, Brush, & Saye, 2009). For instance, Albers, Pace, and Odo (2016) studied participants' messages that they posted in a forum about their activities within an oTPD to identify the different ways that participants were using the PD. Similarly, by using teachers' surveys on PD activities, Liu (2012) revealed themes of teachers' perceptions of valuable processes in a social oTPD, including participation in a learning community, self-reflection, group discussion, activities that promote "noticing" effective teaching, activities that have participants revisit teaching practice, and aligning PD activities with everyday workload to reduce difficulty in participation. In another example, Rolando et al. (2014) investigated whether teachers performed expected tasks within an oTPD, noting that most teachers performed above the level of minimum expectation within the studied program. By contrasting teachers, Rolando and colleagues also found that certain actions in the PD can be used for more than one purpose, such as the viewing of discussion forum posts for information gathering, exploration, network building, and camaraderie.

In contrast to the use of individual teachers' data for the grain size of interest, some studies also examined group-level dynamics of teachers to explain PD processes. Laurillard and colleagues (2016) investigated five massive open online courses (MOOCs) used for oTPD to investigate how online communities form and interact with content. By analyzing community interactions and group collaboration, their finding was humbling in that teachers found it difficult to engage in collaborative activities due to structural constraints of online environments that can make social interaction sometimes less personal and difficult to work together on projects with people that don't work closely together in person. Using another approach, Kellogg, Booth, and Oliver (2014) studied teachers' social interactions within a PD MOOC to identify types of participation. Using teachers' social messages within a MOOC as a data source, they used social network analysis to identify teachers who were both core and peripheral participators within the program, investigated whether different social groups within the program interacted in the same ways, and identified the types of knowledge that were shared among groups. An important finding from this study revealed that the network structure of groups within the oTPD that was studied mimics the network structures of other social phenomena, such as communities of practice and face-to-face professional learning networks.

Although it is true that the varying grain sizes in the aforementioned teacher-level studies each represent different units of analysis in their own right, each of these layers also reflect teachers *only*. Based on these results, the field has been engaging in answering pressing questions about the influence of PD on teacher practice as a component of effective PD (Ball & Cohen, 1999; Dede et al., 2009; Desimone, 2009; Garet et al., 2001; Lawless & Pellegrino, 2007). However, although there were many investigations on teacher-level knowledge and practice in the previous decade related to oTPD, this focus on teachers did not necessarily mean that these studies answered critical questions about the *efficacy* of oTPD programs and their constituent features. In fact, as discussed previously in Section 3.2 on research methods, only a handful of the studies with teacher-level units of analysis in this review employed an efficacy-style design. This leaves the field with unanswered questions about the degree to which the rich variety of oTPD programs over the previous decade met their intended goals of influencing teacher knowledge, beliefs, and practices.

2.3.3.2 Program-Level

In contrast to the teacher-level, some scholars employed units of analysis that measured aspects of oTPD programs as a whole unit, with 23 studies utilizing program-level units of analysis to some degree. The types of studies that employed program-level units of analysis included holistic program evaluations and analyses related to how programs are provided at a larger scale or are implemented in different contexts.

The largest proportion of studies that utilized program-level units of analysis were those that performed evaluations of a whole “packaged” oTPD intervention, with 19 studies using program-level units toward this end. A general trend within this category is characterized by data to answer research questions of whether implemented interventions (considered at the whole or single-program level) performed with adequate levels of expected performance or satisfaction for both the designers and participants. In one example, Cavanaugh and Dawson (2010) provided a detailed description of an oTPD implementation, as well as a brief evaluation of whether the various features performed to the expectations of the researchers. The researchers investigated a number of program-level variables that were largely measured with thresholds of adequacy that could be measured in a yes/no fashion, such as whether program features were valuable to participants, whether features allowed participants to interact in the way they were intended, and whether the program delivered the intended content. In this case, the number of subjects for each variable they used was one, which represented the individual program itself. In looking at similar aspects of oTPD, Cho et al. (2013) described the implementation of an oTPD intervention by investigating whether an implemented program was able to provide desired types of interactive affordances by the researchers. Again, the number of subjects in this analysis was one: the single implemented oTPD program. Although many of the reviewed evaluations in this category also included teacher-level variables and associated research questions, the above-mentioned studies investigated program-level variables to some degree by providing rich descriptive narratives that provide readers with an understanding of the design and features of the PD.

Although they are empirically based, the descriptive program evaluations that were observed in this review largely failed to provide the level of rigor that scholars have determined as necessary in the field for both identifying the effective elements of oTPD programs (Hochberg & Desimone, 2009; Lawless & Pellegrino, 2007; Penuel et al., 2007) or for testing theories of professional learning (Dede et al., 2009; Wayne et al., 2008). As mentioned in Section 3.2.2., holistic program evaluations that use rich descriptive accounts for methodology are valuable for the continued development of design knowledge and for understanding the contexts in which programs operate. However, within this review, program evaluation reports and other descriptive accounts complemented well other rigorous research questions, such as studies that included both program evaluative descriptions and examined program efficacy (Al-Balushi & Al-Abdali, 2015; Martin et al., 2016; Wang et al., 2014) or processes of learning (Francis-Poscente & Jacobsen 2013; Ming et al., 2010; Seraphin et al., 2013; Shea, Mouza, & Drewes, 2016).

Albeit much less prominent than that of program evaluations, another trend in the use of program-level units of analysis was the investigation of questions related to how oTPD interventions perform in different contexts so that they might be delivered at a larger scale. Two studies illustrate this trend well. First, Fishman et al. (2013) investigated the feasibility of almost-identical PD programs that only differed in their location of delivery (face-to-face and online). As a result, they found no significant differences between the implementation of the two programs across several variables, including participant satisfaction, the use of program features and activities, and amount of time spent by participants between the two conditions. In this rare example, these scholars offered virtually the same program in multiple contexts to specifically address questions about the feasibility of program scale. Similarly, Seraphin et al. (2013) examined multiple implementations of an identical program in different face-to-face and online contexts, finding that only the informational content that was delivered by programs and discussed among participants tended to differ between programs, as participant groups in different contexts will naturally drive conversations about professional learning topics based on their particular needs and interests. As such, they recommend a degree of flexibility around content be afforded in oTPD programs in order to promote adaptive scalability.

Toward goals of scalable PD programs, scholars in recent years have repeatedly expressed the importance for the field to ask questions about scalability of PD programs, for which program-level units of analysis are appropriate (Borko, 2004; Garet et al., 2001; Hochberg & Desimone, 2010; Penuel et al., 2007). oTPD is well poised to offer professional learning opportunities at a large scale with considerably lower resources when compared to its face-to-face and hybrid counterparts. However, as of this previous decade, it appears that this area of research continues to be underdeveloped with only two studies addressing these questions.

2.3.3.3 <u>Student-Level</u>

A persistent challenge in the field of PD research is the need to link teachers' participation in PD to student achievement. Scholars have contended for years that an additional focus on student outcomes is essential for the advancement of the PD field (Fishman et al., 2003; Garet et al., 2001; Lawless & Pellegrino, 2007; Penuel et al., 2007). Despite this mandate from the field's scholars, the previous decade of oTPD research has demonstrated little growth in general research trends toward examining student outcomes.

Only 6 oTPD studies from the previous decade examined student-level variables in connection with teacher participation in oTPD interventions. In an excellent illustrative case of the use of student-level units of analysis, Fishman and colleagues (2013) sought to investigate differences between online and face-to-face PD programs with identical content and activities. As expected, they investigated whether programs differed on teacher-level outcomes, finding no significant differences between online and face-to-face PD with teacher-level outcomes such as knowledge, confidence, and fidelity of implementation of curriculum as a result of participating in either PD. However, Fishman and colleagues also investigated whether teacher participation in either PD type had any demonstrable effect on their students as well. Gathering achievement data from the individual students in each of the teachers' classrooms, they additionally observed no significant differences with student learning outcomes between PD types.

In a similar fashion, Malancon et al. (2014) investigated an oTPD designed to support teachers' fidelity of implementation of a high-school science curriculum by investigating changes in teachers practice as teachers participated in an ongoing oTPD intervention, in addition to improvements in students' knowledge. Along with teacher-level data, Malancon and colleagues also collected student-level data at both the beginning and end of the oTPD in a pre-post observational design. Although student changes were indirectly influenced through their teachers' implementation of the curriculum, they concluded that the oTPD program supported student achievement as students showed significant growth between the pre- and post-PD assessments on biomedical science content knowledge and science skills. It is true that this was not an experimental study that utilized a control condition, nor was the study able to determine the unique effect that the oTPD intervention had on student outcomes. However, this observational-type study demonstrated an important step toward including student-level data in assessing whether oTPD programs achieve the more distal goal of influencing student achievement.

Finally, Wang et al. (2014) utilized a design-based research (DBR) approach to iteratively design and subsequently improve an oTPD for teachers, with an expressed goal of influencing student learning outcomes. To accomplish this, Wang and colleagues tracked successive years of an oTPD and the changes to the program design each year, with each year accounting for both teacher-level and student-level outcome variables. If measured in a rigorous way, the authors argued that evidence of changes between years can be used to infer at least partial influence of oTPD on teachers and students through the changes made. They also recognized the realistic limitations of doing traditional experimental efficacy studies in educational settings with both students and teachers, as their study uses the same teachers but different students for each year because of students moving to the next grade. However, despite these limitations, Wang and colleagues compared the sequential yearly iterations of PD to track changes in teacher practices and student achievement, finding that student content knowledge and skill outcomes were higher with each successive year. Wang and colleagues recognized that oTPD programs are intended to ultimately influence student achievement. By tracking student achievement across the years, they were able incorporate empirical evidence about program efficacy toward student achievement into their process of successive design iterations.

The three exemplars discussed above that used student-level units of analysis reflect important steps toward the field's goals of recognizing the ultimate impact of oTPD on student achievement. However, with only 6 of 54 studies in this review having included student-level variables, there has not been a substantial trend toward investigating student impact resulting from oTPD. Research designs that incorporate the field's mandate for student-level analyses will bolster the mission of the oTPD community to provide meaningful and effective programs to support both teacher and student learning.

2.4 Gaps in the Literature: Measuring Program Efficacy while Accounting for Teacher Participation in Individual oTPD Program Features

The review of the literature in the sections above illustrates the collective direction of the field from 2007 to 2017. In general, the three focal areas reveal an alignment of the scholarly work from the past decade with a few of the concerns and mandates raised by the research community concerning the design and research of PD programs. However, this broader research agenda set by the field has only been partially addressed by these studies, with some areas of the agenda not demonstrating any progress over the decade. Toward this agenda, this review additionally identified areas for research that remain underdeveloped, which largely echoes the findings of past reviews on PD from different time periods (Dede et al., 2009; Lawless & Pellegrino, 2007). In summary, multiple areas within oTPD structure, research design, and units of analysis continue to have gaps in the type of work that has been deemed necessary for continued growth in the field.

The authors of the studies in this review have often provided rich descriptions of the different features within oTPD, how features were implemented, and how these features worked in practice. Rich descriptions will be increasingly necessary in future years as new technologies are developed, are refined, and applied by researchers in new ways for oTPD. A second positive trend among studies was that researchers have made many advancements in understanding the processes of learning and how participants interact in a variety of oTPD contexts, particularly within social dimensions of PD. Indeed, much focus has been recently cast on the social elements of oTPD programs, as demonstrated by the large number of studies in this review that investigated multiple aspects of teacher learning and PD processes in socially mediated oTPD programs, either between peers, or also with coaches and PD staff. Social oTPD programs have promise to afford teachers a more authentic form of learning from which they can learn from their peers' experiences in the classroom, which can be connected to their everyday work. Toward meeting the research agenda, work that provides inventories and rich descriptions of social processes in oTPD has been valuable to understanding the different ways that teachers interact in interventions.

Many new positive trends have additionally emerged over the last decade regarding the design and conduct of oTPD programs and research, as well. For instance, scholars have been attentive to the novel affordances that cloud computing, mobile devices, and ubiquitous internet access can provide to oTPD programs. Technologies such as social networks, notifications, badging, and even synchronous and asynchronous communications have significantly increased in their capacity to connect people. Additionally, because oTPD programs afford greater flexibility to participants through the use of web-based technologies, scholars have embraced opportunities to provide personalized experiences to teachers. This includes the substantial increase in studies that report hybrid learning experiences that aim to leverage the best parts of both online and face-to-face PD, as well as an increased emphasis on providing long-term and flexible-duration oTPD programs (including self-paced programs). In addition, the commitment to providing social oTPD experiences is both well-grounded in the theoretical literature on professional learning but is also more feasible today than ever with the ubiquity of internet connectivity and the ability to equally experience oTPD programs through any number of devices, platforms, or applications. The ability for oTPD designers to provide connected learning experiences for professionals, both in terms of connecting people to information and peers, has perhaps never been more achievable based on today's widespread access to devices and the Internet. Thus, it is timely and necessary that much research on how people interact in these contexts has been accomplished over the last ten years.

However, the studies in this review collectively fell short on addressing many of the research agenda items laid out by leaders in the field. First, although some studies from the previous decade investigated oTPD program effectiveness, it was nonetheless a small number of studies. In order to make informed decisions about how to improve oTPD programs and where to place investments that will have an impact, it is essential to know the degree to which programs and their implemented design features work. This search for program effectiveness also doesn't preclude the need for research that examines the process of learning in PD interventions.

Although the field indeed needs more program effectiveness studies that examine the different contexts in which oTPD is used, process-based studies can help inform the research design of efficacy studies by articulating the different types of interactions and contexts that should be considered within formal efficacy research models. Studies investigating the processes and types of interactions of participants in oTPD can help answer the *why* part of the field's mandate to answer "what works and why" (Lawless & Pellegrino, 2007). The design-based research (DBR) study by Wang et al. (2014) is a good example of a research program that has value for investigating both program effectiveness and the processes of how people learn within them, which can be subsequently used to inform improved designs of oTPD. Given appropriate considerations for rigor, multiple research foci can be addressed in the same research program.

Second, there remains a substantial lack of research that examines the relationship of professional development interventions to student-level achievement. For over 20 years, scholars have been calling for a greater emphasis on examining the ultimate influence that PD programs have on students (Borko, 2004; Garet et al., 2001; Fishman et al., 2003; Penuel et al., 2007). However, with respect to student outcomes, this review reflects the same findings as other reviews that have come before it, with little progress being made in this area in the last decade (Desimone, 2009; Lawless & Pellegrino, 2007; Wayne et al., 2008). To make sound investments in professional development research and design through both financial resources and teacher time, it is essential to further develop the field's knowledge base on how PD interventions ultimately influence student achievement (Wayne et al., 2008). Within this context, studies in the future should address student-level outcomes whenever such designs are appropriate.

Third, scholars have increasingly argued that variations in the level of teacher participation in oTPD programs should be measured and considered by researchers (Henrie, Halverson, & Graham, 2015; Hochberg & Desimone, 2010; Hrastinski, 2009; Wayne et al., 2008). However, studies that examined program effectiveness in this review did not account for variations in the experience of participants. Both conventional experiments and single-group observational studies often assume that the participants, considered in aggregate, will provide a reliable measure of the group experience despite any variation that occurs within the group. However, this basic assumption is challenged with the use of oTPD interventions. The very nature of oTPD affords participants to have different, flexible experiences based on their needs or interests (sometimes to a dramatic degree). Therefore, it is becoming increasingly difficult to conduct research in this field with an assumption that participants in online, flexible, self-paced, or otherwise unsupervised interventions indeed are exposed to the same intervention. Relying only on assigning participants to treatment and control experimental conditions when conducting research with oTPD interventions discounts the observations by numerous studies in this review that each participant experiences online programs in different ways.

In terms of education research, there is value in defining and measuring oTPD participation as it allows researchers to know how much of the intervention each subject received. Including participation as an independent variable in investigatory models would serve to strengthen the internal validity of studies by considering participation as both a potential moderating variable (i.e., influencing the strength of the effect of PD) or a mediating variable (i.e., a partial cause of PD effects). In other words, it can better specify the effect that an oTPD program has on teachers, and by extension, students. When formally included in studies, information on both the types of and amount of participation can serve as an important check and balance on what is happening within an oTPD that can complement both quantitative and qualitative analyses in oTPD. In this way, researchers can either ensure that participants are indeed receiving the intervention as intended or can identify elements that are not being used as expected (Wayne et al., 2008). On the other hand, when participation is not measured, researchers have a greater difficulty in pinpointing where in a PD program's logic model any effects are observed (Hochberg & Desimone, 2010; Hrastinski, 2009; Wayne et al. 2008).

Finally, the studies in this review demonstrated a need to better specify the design features in interventions and how they are implemented. The number of technologies and approaches that are available to oTPD designers and researchers has expanded each year, which has revealed unique combinations of tools, approaches, and technologies to each oTPD intervention as reported in the literature. Details on design are thereby important in each published report, even if the descriptions of how a program is designed is offered as supplementary material to the original journal article. This approach benefits researchers as they are better able to compare and understand how features influence the outcomes for both teachers and students and to test the underlying theories upon which features are built (Hochberg & Desimone, 2010; Wayne et al. 2008). Design specificity also informs the work of instructional designers by providing details on the specific tools, technologies, and procedures that were implemented within oTPD programs to aid with replicability and transfer of designs to other contexts (Rice & Dawley, 2009).

2.5 Toward Feature Level Analysis: Measuring Participation within Design Features

Participation within an oTPD can be conceptualized in multiple ways. Each feature within an oTPD can potentially exhibit various types, amounts, and qualities of participation, for which both qualitative and quantitative methods of analysis are appropriate for investigating online intervention participation (Hrastinski, 2008; Wayne et al., 2008). Digital server logs that capture each interaction a participant has with an online learning system are valuable indicators for participation within an oTPD. However, simple frequencies of participation, such as number of clicks or amount of words, may not conceptually account for the “amount of participation” in a way that is rigorous or reliable enough to determine whether more or less of a PD feature supports both professional and student learning outcomes. In this way, basic frequencies of some participation metrics may also be conceptually meaningless due to the presence of extreme outliers and the range of values between cases.

For instance, in a hypothetical example involving measurement of six users’ click frequencies in an online environment, it would be difficult to distinguish meaningful “types” of participation between the six users if each respective user registered 1, 10, 10, 20, 100, and 1,000 clicks within the learning environment. If a researcher only considered the raw frequency of clicks for interpreting these participants’ behavior, it would be difficult to identify any theoretical rationale for the differences in click frequencies, as they are not tied to specific actions within the system other than the action of “clicking” - all clicks are the same. In addition, it would be challenging to statistically analyze any extreme outliers that are represented in click frequency data, which can commonly occur in online environments. Extreme outliers in online log file data are often discarded in such analyses but could still reveal meaningful information what a participant is doing and how they interact in the system. In the above-mentioned six-user hypothetical example, each user demonstrates more or fewer clicks than their peers, which indeed is evidence for variation in participation. However, it remains difficult to determine with much conceptual depth of how the user with 1,000 clicks participated more or differently on than the others and whether its outlier status matters in a meaningful way.

To date, studies that measure participation in online learning environments have typically used such raw frequency data of recorded web server events, such as clicks or page views, without any additional imputation of activity type, content type, or level of difficulty or effort on part of the participant (DeBoer et al., 2014). For more robust inquiries into the efficacy of participation in oTPD programs, conceptually rigorous variables for measuring participation in PD programs that provide additional information about different types, amounts, and dimensions of participation in these environments are necessary in future studies (Hrastinski, 2008; Wayne et al., 2008). Pageviews and clicks from server logs indeed provide initial indicators into the amount of participation with a particular digital feature. However, raw server interaction data from logs can also be used to develop more rigorous participation variables if processed to represent different categories of participation at varying levels.

Another option for inferring additional meaningful levels of participation from server logs is through conceptualizing the expected *level of effort* by participants. As online learning environments have become more prevalent, scholars have argued that the level of effort when participating in an online learning environment can reliably be used as a measure of learning within a digital environment (DeBoer et al, 2014; Hrastinski, 2008, 2009). In its most basic form, participation in a learning environment is, in fact, the act of learning itself: interaction and participation with designed learning activities invokes changes in the learner as mastery is gained (Rogoff, 2003; Wenger, 1999). In online learning, the varying degrees of interaction with and exposure to designed features in an online learning intervention is a reliable representation of a participant's learning processes and activities that lead to improved skills, which can be directly evidenced by server log files (Hrastinski, 2008, 2009). Thus, the level of effort that participants exhibit in an online learning environment can serve as representative indicators of the levels of learning and motivation of participants in such environments as they work through and interact with designed activities.

However, determining meaningfully discrete differences between levels of effort can be difficult if researchers simply examine the number of clicks in an online environment. One click and several clicks over different time periods might nominally indicate different levels of effort, but ultimately be highly correlated with each other and provide no meaningful differences between cases (DeBoer et al., 2014). This presents a challenge to researchers, as sound measures of participation should distinctly identify ranges of activity that are conceptually meaningful if participation is to be understood and reliably represented (Hrastinski, 2009).

2.6 A Previous Pilot Study on Effects of Effort-Based Participation Measures in oTPD

To address the challenge of creating conceptually meaningful participation variables, this study proposes the use of measuring participation within design features by expected level of effort. Operationalizing participants' expected level of effort with design features allows for each value of a scale to be meaningfully connected to an evidenced level of effort, as determined during data processing. Some data sources lend well toward measuring level of effort as an interval-level unit of measure, such as the number of clicks on a webpage or email, length of a segment of writing, frequency of posts in a forum, duration of video watching, or length of spent on a website. However, some data sources that capture digital interactions can also be measured via ordinal progressive levels of effort that are demonstrated by a participant. Provided that the various types of participant interactions within an online feature can be systematically captured via system logs and categorized, each activity within a digital environment can be logically compared with other features.

A measure of the expected level of effort is constructed based on the amount of effort that *must* be present with a given interaction, relative to other interactions that are possible within the feature. As a result, values indicating effort can be assigned from various types of observed behaviors within an online environment. Such variables can be constructed from simple clickstream server log data in an oTPD system. Thus, the amount of participation with each design feature will be operationalized into variables in terms of observably progressive *levels of effort* exhibited by teachers.

To these ends, this dissertation seeks to extend work performed by the author on a prior pilot study featuring measurements of level of effort. In the pilot study, effort-based participation measurement variables for specific oTPD design features were developed from evidence of interaction that was captured in server log files (Riel, Lawless, Brown, & Lynn, 2015). In this study, teacher oTPD participation with two individual digital media components was defined and measured: a weekly email bulletin and a weekly teacher reflective journal. Participation was conceptualized where increasing amounts of use, number of sessions, frequency, and duration of use indicated varying levels of effort. To this end, each successive increase in participation variables for a given design feature signaled additional effort on part of the participant. In any subsequent analysis on student outcomes as predicted by teacher participation in oTPD, higher levels of oTPD participation with both the email and journal features corresponded with higher levels of student learning outcomes. Feature-level evaluations like this study can allow researchers to investigate the simultaneous relative contribution of specific design features in an oTPD intervention toward the achievement of teacher and student outcomes.

Indeed, different types of effort may occur that are not captured by digital server logs. Researchers should be reminded that some oTPD participation behaviors cannot be directly inferred when participants are performing actions outside of the behaviors the server logs can directly observe (e.g., *reading* or *thinking about* an email, *jotting notes* on paper about an activity). Indeed, server logs provide ample information about the exact activities performed *within* the oTPD system, but fail to reveal behaviors outside of counting clicks, pageviews, and elapsed time between page visits. Despite these limitations, though, digital logs can provide at least some direct empirical measures of the level of participation with individual digital features in an online PD course, and these measures can be further validated with future research. Measuring the level of effort from server logs also provides a reliable indicator of the degree to which participants were exposed to or interacted with course activities (via its features) with which evaluations of oTPD program design and effectiveness can be conducted.

As in the pilot study discussed above, conceptualizing participation as the "level of effort" of participants is one useful way for making sense of server log events in terms of what and how much a participant is doing in an online environment. A level of effort measure provides meaningful degrees of participation based on the evidence of "how much work" that a participant did. Although measuring participation by amount of effort is only one of many potential ways of measuring participation, it is a worthwhile study trajectory as researchers have recently determined that the "amount of exposure" to PD interventions is necessary to determine whether varying levels of effort, time, and type of participation matter in achieving desired PD outcomes, similar to considering the "exposure to intervention" or "adherence to dosage" in clinical drug trials (Wayne et al., 2008).

2.7 Research Questions and Hypotheses

As discussed in the literature reviews in Sections 2.1 and 2.2, scholars in the field have repeatedly demonstrated the need for a renewed effort in oTPD research. Specifically, research is needed that examines the following elements: (1) to investigate the effectiveness of oTPD interventions on both teacher practice and student achievement, specifically at the individual feature level of PD programs; (2) to account for the level of experience, participation, or teachers' exposure to oTPD interventions and their features to ensure that the intervention was used by teachers to some degree; and (3) to systematically report on the design of the oTPD intervention, including details on the rationale, design, and actual implementation of each design feature.

To respond to these three elements, the remainder of this dissertation employs the evaluation framework identified in Section 2.2.4 to investigate the effects of teacher participation in the GlobalEd 2 Professional Development Program (GE2PD) by analyzing the level of participation that teachers exhibited with each of the GE2PD design features. The GE2PD was an oTPD that was designed to support teachers' implementation of a curriculum that was new to them, as well as promote new pedagogical practices in teachers' everyday work. The GE2PD is discussed in further detail in Section 3.1.

The following research questions guide this dissertation:

RQ1 — To what degree did teachers use or participate in each of the individual design features in both the "up-front" and ongoing GE2PD portions of the program, as measured by expected level of effort?

RQ2 — To what degree did teacher participation with design features substantially vary between teachers, or was participation uniform across teachers for some design features?

RQ3 — To what degree are individual design features are highly correlated with each other?

RQ4 — What effects do each of the GE2PD design features have on teacher curriculum implementation adherence?

RQ5 — What effects did each of the individual design features in the up-front GE2PD portion ultimately have on distal student outcomes of argumentative writing skills?

RQ6 — What effects did each of the individual design features in the ongoing GE2PD portion ultimately have on distal student outcomes of argumentative writing skills?

RQ7 — What effect does teacher curriculum implementation adherence have on student achievement, as measured by argumentative writing skills?

Hypotheses are provided to allow for direct tests of the efficacy of the GE2PD on both teacher practice and student achievement. The following hypotheses direct the investigation of the eight research questions:

H1 — In aggregate, teachers exhibited substantial levels of participation in each of the GE2PD individual design features.

H2 — Each of the GE2PD design features exhibited substantial variation in the level of participation between teachers.

H3 — There are no large correlations of teacher participation levels between GE2PD design features (but low to moderate correlations are expected).

H4 — Each of the design features in both segments of the GE2PD (i.e., upfront and ongoing) had a positive direct effect on teacher curriculum implementation adherence.

H5 — Each of the design features of the up-front portion of the GE2PD had a positive indirect effect on desired distal student achievement, measured as scientific argumentative writing.

H6 — Each of the design features of the ongoing portion of the GE2PD had a positive indirect effect on desired distal student achievement measured as scientific argumentative writing.

H7 — Teacher curriculum implementation adherence had a direct effect on student achievement in scientific argumentative writing.

The eight hypotheses provide direct opportunities to test the research questions. As each of the design features of the GE2PD were intentionally implemented to realize program goals, it should be expected that each feature was indeed used by teachers, else the features could not impact the desired outcomes (i.e., H1). Additionally, it is expected that there will be variation in the participation levels within design features, as participants could approach design features flexibly on their own time and with different levels of participation (as reflected in H2). As each design feature served a unique purpose, it is also initially assumed that GE2PD design features are not highly correlated with other features (e.g., H3). Finally, teacher participation with each design feature is assumed to have effects on both teacher practice and student achievement, as each feature is intentionally implemented for this purpose (e.g., H 4-7).

CHAPTER 3: METHODS

3.1 Context of the Study: The GlobalEd 2 Professional Development Program (GE2PD), an oTPD to Support Curriculum Implementation

This portion of the dissertation reports an evaluation of the individual features of a previously implemented oTPD called the GlobalEd 2 Professional Development Program (GE2PD). The GE2PD was an oTPD program with the direct primary goal of supporting teacher implementation of the GlobalEd 2 (GE2) curriculum. Specifically, the program designers intended that participation in the GE2PD would influence teachers' implementation of prescribed curriculum activities as well teachers' general use of PBL pedagogy. This goal was to be accomplished through continual weekly support of teachers as they implemented the GE2 curriculum.

The GE2 curriculum (www.globaled2.com) is a set of problem-based, interactive negotiations simulations in which students from middle school social studies classrooms collaboratively develop solutions to real-world problems across classrooms. In a GE2 simulation, students play the role of an assigned country at an international negotiations summit in which they send and receive negotiations messages with students from other classrooms in an online communications system. Students are tasked with developing an agreement with at least one other "country" (i.e., classroom) during the duration of the interactive simulation. By actively working on solving a real-world scenario, teachers can leverage problem-based learning principles to encourage students to actively apply the knowledge they gain from their research and negotiations on the problem scenario, as well as to learn how to connect science and social studies concepts across disciplinary boundaries. Numerous lesson plans, student scaffolds, and interactive activities were provided to teachers in the GE2PD to guide students' research and negotiations.

As many of the pedagogical approaches, technologies, and activities in the GE2 curriculum were new to many teachers participating in GE2, it was expected that a substantial amount of professional development support would be beneficial to teachers. Thus, PD was provided in both an up-front course when they first agreed to participate in the curriculum, and in an ongoing manner where support was provided on a weekly, on-demand basis as they implemented the curriculum. The content of the ongoing GE2PD was dynamic, as it depended upon the weekly issues, challenges, and interests expressed by the teachers as they actively implemented the GE2 curriculum.

3.1.1 Goals of the GE2PD — Supporting Curricular Fidelity of Implementation

The primary goal of the GE2PD was to promote the implementation of the GE2 curriculum. Toward this goal, it was important to support teachers' ability to perform the specific curricular tasks associated with GE2. The implementation of intended practices and curricular activities is often referred to in the literature as curricular fidelity of implementation (FOI), a concept that describes the degree to which teachers implement curricula in ways intended by instructional designers. Scholars have largely determined that curricular fidelity of implementation typically consists of a range of four complementary elements (Dane & Schneider, 1998; Gersten, Baker, Haager, & Graves, 2005; Gresham, MacMillan, Beebe-Frankenberger, & Bocian, 2000): (1) the *adherence* to specific curricular designs, (2) the *quality* of instruction given, (3) providing *adequate time* toward implementing the intervention, and (4) the ability to flexibly *differentiate and adapt content and activities* while applying the underlying educational theories and principles upon which the the curriculum is designed (Hammerness et al., 2005). Each of the four elements work together to provide students with experiences intended by instructional designers that meet the theoretical commitments and underpinnings upon which curricula are based. Thus, for anticipated effects to be realized, it is important for teachers to implement curricular interventions with a high degree of fidelity to the intentions of curricular designers (Gresham et al., 2000; Hammerness et al., 2005).

Indeed, all four above-cited elements of curricular fidelity of implementation are important in promoting ongoing teacher professional practice and supporting student achievement with specific curricula. However, a chief element of a curricular efficacy study is to investigate the adherence to curricular expectation. Any investigation of adherence to curricular activities should reveal specific aspects of how curricular interventions are adopted and whether curricular activities are adopted according to expectation. Researchers and designers alike can safely assume that measuring teacher adherence to curricular activities, tasks, and lessons is perhaps the highest priority, as measuring *what activities* and *how much of an activity* a teacher is implementing provides baseline data for measuring and interpreting the other three elements of curricular fidelity. In effect, the adherence to prescribed or expected curricular activities serves as a valuable indicator of *what* teachers are directly doing with the curriculum. Measurement of adherence additionally provides a common frame of reference and definitions of teacher activity to understand imbalances between how teachers implement curriculum and what instructional designers expect. Thus, the identification of the other three elements of FOI (e.g., quality, time, and differentiation) predominantly requires an initial understanding of what teachers are doing with curriculum, which can be reliably analyzed by measuring the degree to which teachers adhere to curricular expectations.

Wayne and colleagues (2008) additionally describe the necessity of measuring adherence to curricular tasks as a fundamental component of tracing the *chain of logic* in an intervention, which is the expected, principle-based activities and outcomes in the design. Wayne and colleagues argue that for any PD program, a chain of logic should start at teacher PD participation activities, proceed to effect teacher curriculum implementation activities, and then subsequently promote student achievement. They additionally argue that a chain of logic must be represented in evaluations of PD efficacy to enhance rigor, as the underlying theories and principles upon which PD and curriculum are designed can be directly tested to determine whether interventions work as expected. Along these same lines, departures from expected PD participation patterns and divergence in adherence to expected curricular implementation patterns can indicate the presence of misalignment in conceptual models and designs, which present opportunities for theoretical refinement, intervention improvement, and further research.

It can also be safely assumed that each feature and activity within a curriculum is intentionally included in the instructional design, with each feature intended to have a specific, desired effect based on the rationale, principles, or theories held by the designer (Guskey, 2000). Thus, it is additionally a reasonable assumption that a high level of curriculum adherence should also align with intended curricular effects, in contrast to a low level or no level of adherence having no effect (Hochberg & Desimone, 2010; Wayne et al., 2008). As a result, any evaluation of an oTPD's effects toward supporting curriculum implementation would benefit from investigating the degree to which teachers adhered to the expectations of curriculum implementation while exposed to an oTPD program. Although other aspects of FOI can and should be investigated as well, adherence to curricular expectations should *at the least* be measured in efficacy investigations to provide evidence for broader questions of how and why PD programs work to support curricular reforms (Dede et al., 2008; Lawless & Pellegrino, 2007; Wayne et al., 2008).

In this dissertation, only the adherence element of FOI is investigated, as the GE2PD was intended to directly support the implementation of the GE2 curriculum at a high degree of adherence.

To better specify the promotion of the *adherence* dimension of fidelity of implementation of the GE2 curriculum via the GE2PD, this goal can additionally be subdivided into three specific desired outcomes:

1. *Specific curricular activity implementation adherence.* It was expected that the GE2PD would further enable teachers to implement specifically prescribed curricular activities by certain deadlines that were essential for the multi-classroom simulation to function properly. Such prescribed activities in the GE2 curriculum included having students post a written opening statement in the online GE2 simulation, support students' continual research on their assigned country, and have students prepare a closing proposal at the end of the GE2 simulation.
2. *PBL pedagogy use adherence*. The GE2PD was intended in-part to promote teachers' proficiency in and active use of problem-based learning (PBL) pedagogies and strategies as part of implementing the GE2 curriculum.

3. *Technology use adherence*. It was also expected that participation in the GE2PD would promote both teachers' knowledge of and active use of specific digital and online technologies used in the GE2 curriculum.

Teachers' implementation of the GE2 curriculum was intended to directly impact student achievement. Specifically, the GE2 curriculum was intended to develop student achievement in at least one key area: students' scientific argumentation writing skills and the activities that support writing. Thus, the GE2PD was also expected, indirectly by extension, to influence distal student achievement via supporting teachers' implementation of the GE2 curriculum.

3.1.2 Design Features of the GE2PD

The GE2PD was divided into two components, each representing a distinct period during the PD. The first component of the GE2PD was the *up-front, online training* that teachers received to familiarize themselves with the both GE2PD and GlobalEd 2 curriculum in preparation for teachers' implementation of the curriculum. Teacher participants completed the up-front portion of the GE2PD during the summer before they began implementation of the GlobalEd 2 curriculum. Teachers were able to complete the up-front component over a three-week period. Course activities were entirely self-paced, allowing teachers to complete course modules when they desired.

The second component of the GE2PD was the *ongoing support or responsive online professional development* (ROPD, Riel, Lawless, & Brown, 2017). In this ongoing component, teachers participated in continual development activities on a weekly basis in partnership with

GE2 staff to support teachers as they implemented the GE2 curriculum in real time. Because of its ad-hoc design and open-ended approach to address specific needs of teachers each week, the level of participation that a teacher could commit in this component of the GE2PD was highly flexible and could vary substantially between participants. In addition, the content of the ongoing PD was dynamic from week to week, based on the scheduled curricular activities that teachers implemented and any challenges that arose for teachers during any given week of implementation that needed to be addressed.

Within these two program components, a total of six design features were implemented in the GE2PD. Teacher participation with each feature in the GE2PD was voluntary, although teachers were required to complete each of the instructional modules in the up-front component to proceed to curriculum implementation. In addition to the program's voluntary nature, each feature afforded teachers a broad range in the degree to which they could participate in each activity or make use of a given feature (especially in the ongoing PD component).

Up-Front Component

1. *Module videos*. Seven instructional modules provided background information on the GE2 curriculum, effective instructional strategies, necessary technology practices, and background on the science, social studies, and writing content that students would encounter in the curriculum. In addition, as the GE2 curriculum was a part of a multi-year research program, teachers were informed of the research components of the project as well. Each module consisted of several videos recorded by experts on each module topic. Teachers could watch any length of a video they desired, and could re-watch any video at will. In addition, teachers could navigate freely between videos and watch them out of the

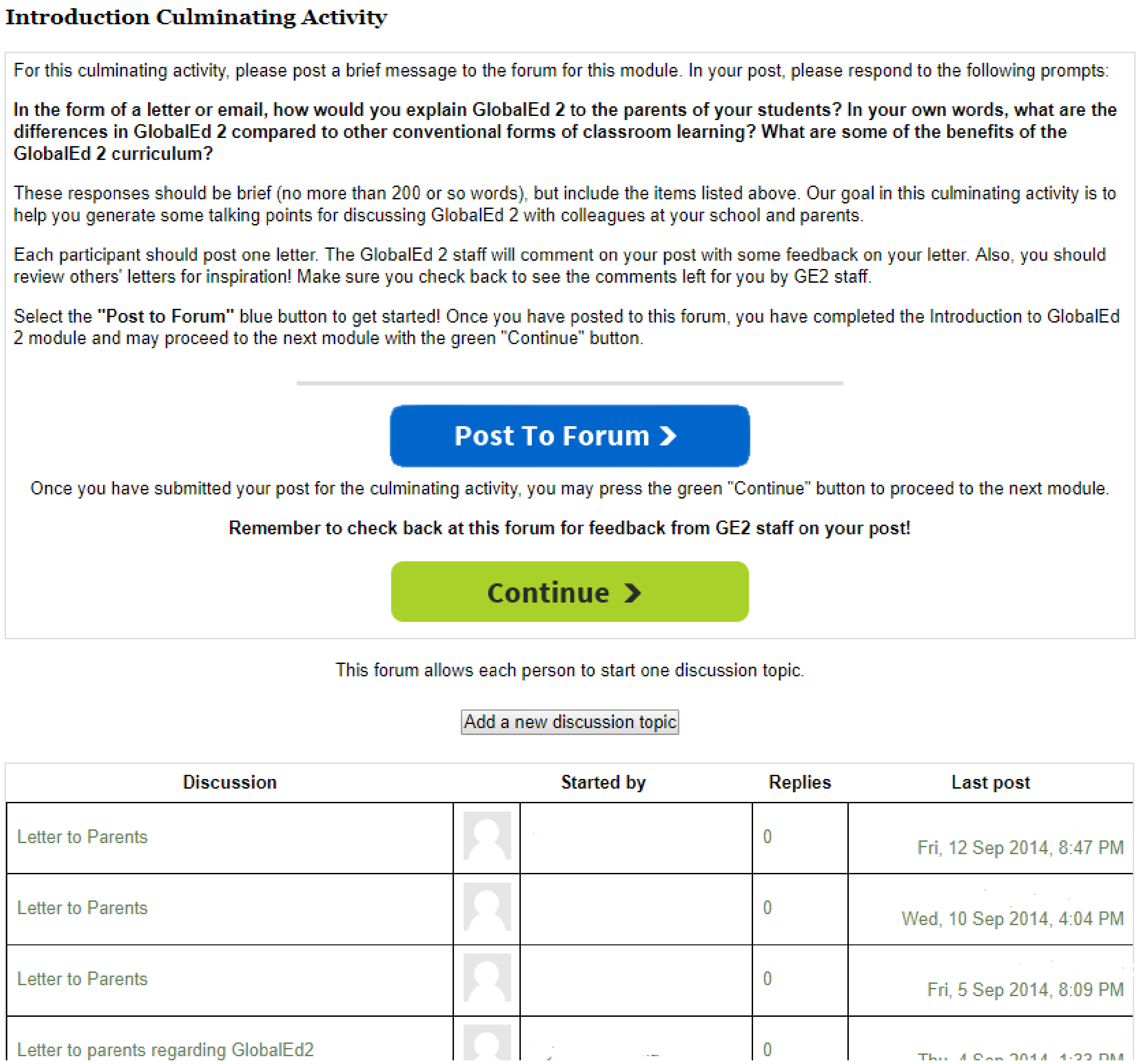
suggested order, if they desired. Videos were delivered via the Vimeo web video service and placed into the instructional modules using the Moodle (www.moodle.org) digital learning management system (LMS).

Additionally, rapid comprehension check quizzes were provided between each video. However, because the comprehension checks were simple quizzes about the content in the immediately preceding video, every teacher scored the maximum number of points on these quizzes and thus did not demonstrate variation in teacher participation. Figure 4 provides a screenshot of a sample module video within the Moodle LMS interface.

Figure 4. Sample module video in the Moodle LMS

2. *Module written activities*. At the conclusion of each module, teachers completed a written culminating activity related to the topic of the module. Each writing activity was designed to provide teachers with a ready-to-use document that could be immediately implemented in their classroom during implementation, such as lesson plans, organizing tools, and assessment rubrics. To complete each writing activity, teachers used material from the module videos and supplemental resources to compile the document. Teachers posted their written documents on a discussion forum at the end of each instructional module. Teachers were asked to provide feedback to other teachers' work with ideas and additional perspectives on the written works. The GE2 project staff additionally provided feedback to each teachers' written work in each module.

    Teachers could submit any written document for each module as long as fulfilled the specifications for the task. The level of writing quality and depth could vary between both teachers and modules. The discussion forums for posting and commenting on written culminating activities in each module were implemented using the forum function in the Moodle LMS. In Figure 5, a screenshot of a writing activity discussion forum in the Moodle LMS is provided. Figure 6 provides a screenshot of a sample written activity posted by a teacher at the end of a module, with other teachers and GE2 staff having provided feedback on the project.



Introduction Culminating Activity

For this culminating activity, please post a brief message to the forum for this module. In your post, please respond to the following prompts:

In the form of a letter or email, how would you explain GlobalEd 2 to the parents of your students? In your own words, what are the differences in GlobalEd 2 compared to other conventional forms of classroom learning? What are some of the benefits of the GlobalEd 2 curriculum?

These responses should be brief (no more than 200 or so words), but include the items listed above. Our goal in this culminating activity is to help you generate some talking points for discussing GlobalEd 2 with colleagues at your school and parents.

Each participant should post one letter. The GlobalEd 2 staff will comment on your post with some feedback on your letter. Also, you should review others' letters for inspiration! Make sure you check back to see the comments left for you by GE2 staff.

Select the **"Post to Forum"** blue button to get started! Once you have posted to this forum, you have completed the Introduction to GlobalEd 2 module and may proceed to the next module with the green "Continue" button.

Post To Forum ›

Once you have submitted your post for the culminating activity, you may press the green "Continue" button to proceed to the next module.

Remember to check back at this forum for feedback from GE2 staff on your post!

Continue ›

This forum allows each person to start one discussion topic.

Add a new discussion topic

Discussion	Started by	Replies	Last post
Letter to Parents		0	Fri, 12 Sep 2014, 8:47 PM
Letter to Parents		0	Wed, 10 Sep 2014, 4:04 PM
Letter to Parents		0	Fri, 5 Sep 2014, 8:09 PM
Letter to parents regarding GlobalEd2		0	Thu, 4 Sep 2014, 1:33 PM

Figure 5. Discussion forum of writing activity

Introduction Culminating Activity

Display replies in nested form ▼

Move this discussion to ... ▼ Move

GE2 Parent Letter

by - Wednesday, 23 July 2014, 6:24 AM

Dear Parents,

We are pleased to inform you that your child will be participating in an innovative and exciting learning experience called Global Ed2. In Chicago we have an abundance of fresh water to meet our everyday needs, yet millions of people around the world in different countries lack access to clean fresh water. As a result, every 20 seconds a child dies somewhere in our world due to contaminated water. Our class is going to explore this issue and work to come up with a solution to the problem through the Global Ed2 project.

Global Ed2 is a research project and unique learning experience run by joint efforts between professors at University of Illinois Chicago and University of Connecticut. A problem-based learning experience like this departs from more traditional classroom experiences by challenging our students to make decisions democratically based upon evidence gathered through their own research. The purpose of the project is to provide a real-world problem-based online learning experience that sharpens our students' knowledge and skills in research, writing, social studies, and science. Our students will be communicating online in safe and moderated forum with students from schools here in Chicago, as well as from schools in Connecticut. Each school will represent the viewpoint of a different country of the United Nations, thus helping our students to learn empathy and compassion for other cultures around the world. As this project involves critical thinking throughout, students participating in Global Ed have shown increased scores on standardized testing, which is essential as your child transitions into high school after this school year. We look forward to keeping you updated as we embark on this exciting Global Ed2 project this year!

Sincerely,

and the middle school teaching team

Edit | Delete | Reply

Re: GE2 Parent Letter

by - Wednesday, 23 July 2014, 6:53 AM

WOW! This letter is terrific! I really like the way that you set up the water scenario for parents... I think we are going to have a fun time together with GE2 and your students :) Enjoy the rest of the PD and "see" you online for the live demo...

Show parent | Edit | Split | Delete | Reply

Re: GE2 Parent Letter

by - Wednesday, 23 July 2014, 1:03 PM

Thank you so much for this amazing opportunity for our students and me! I know my students will be really excited for the challenge and the overall experience!

Show parent | Edit | Split | Delete | Reply

Figure 6. Sample written activity with dialogue from other teachers and GE2 staff

3. *Mini-simulation participation.* To prepare teachers for the interactive, online negotiations component of the GE2 curriculum, a one-day "mini-simulation" was conducted for teachers. The mini-simulation was intended to give teachers direct experience with the online environment in which their students would be interacting during curriculum implementation. Teachers were assigned the role of a country and were tasked with working with other "countries" in the online negotiations environment to solve an international crisis, specifically an oil spill off the coast of Greece. The simulation gave teachers proficiency in the online negotiations environment used in GE2-based simulations and provided teachers an opportunity to practically apply problem-based learning, science, social studies, and writing content that the teachers encountered during the up-front PD. Because the negotiations simulation was open-ended and discussions were participant-driven, the levels of participation and effort between teachers in the mini-simulation could vary substantially. The online mini-simulation was implemented using the ICONS software, a text-based interactive platform designed to support multilateral international negotiations simulations (www.icons.umd.edu). Figure 7 provides a screenshot of the teacher mini-simulation conducted in the ICONS software.

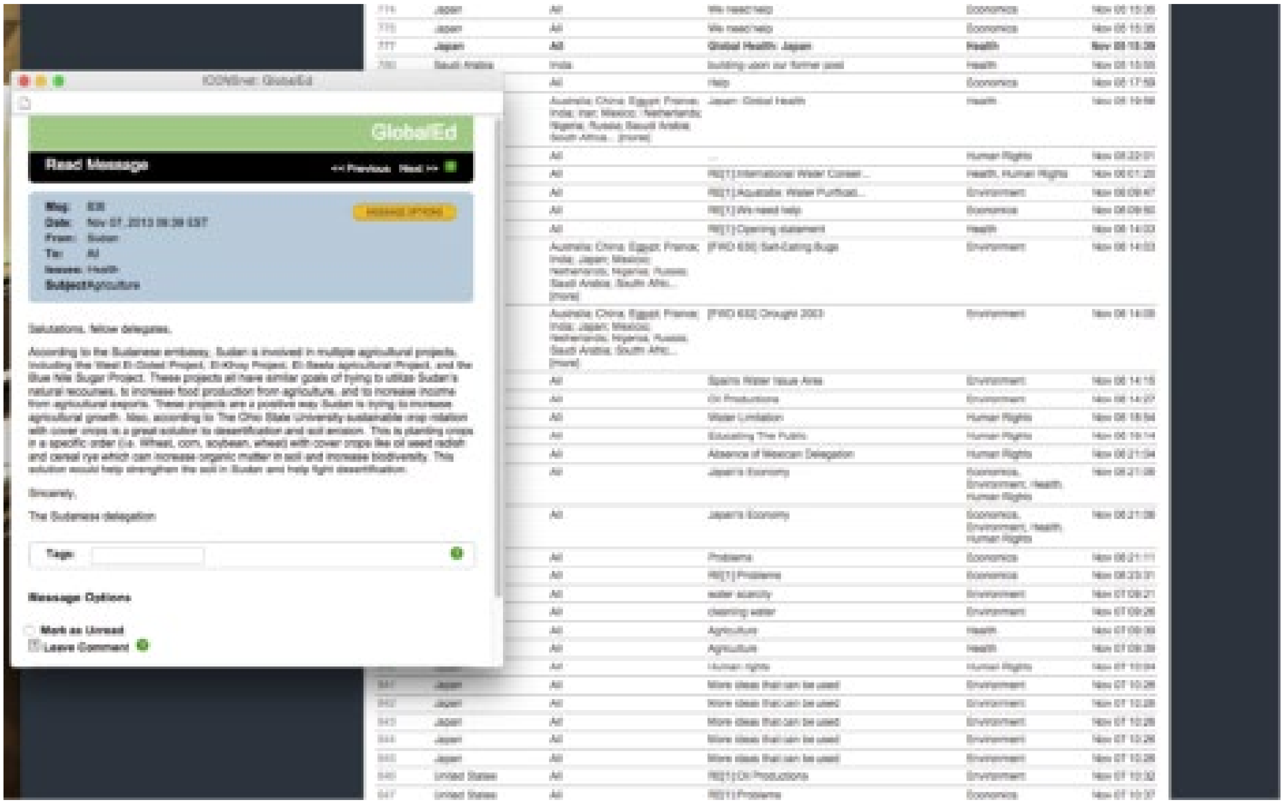


Figure 7. Screenshot of teacher mini-simulation dialogue interface in the ICONS software

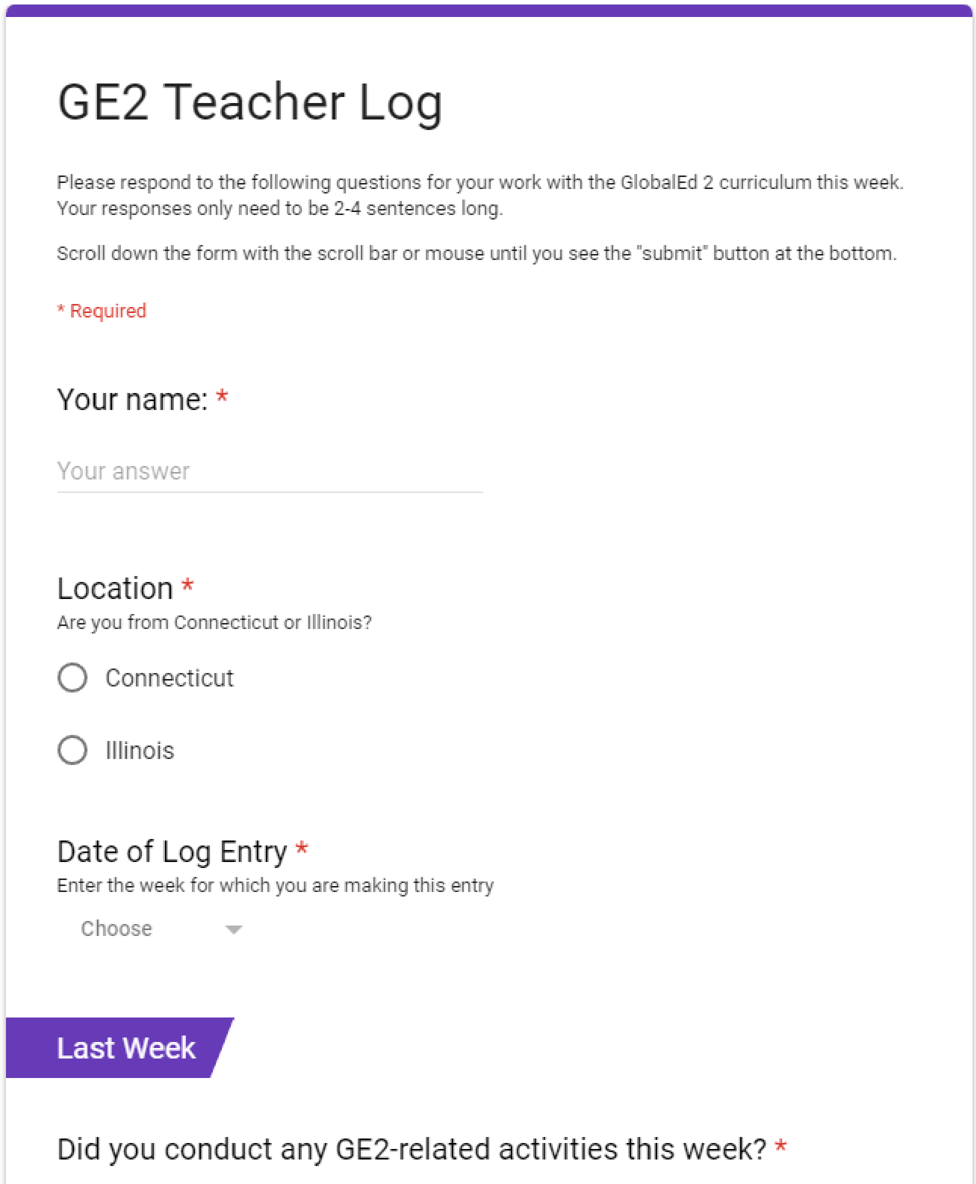
Ongoing Component

4. *Teacher log*. Teachers completed weekly teacher journals called “teacher logs” via a web-based form. Each week, teachers were asked to submit responses to short, written prompts about the teaching strategies, student activities, and curricular resources that were used during the previous week. Teachers were also asked questions about how the GE2 curriculum staff could help with implementation, or if there were any issues or challenges that arose in the previous week with which the GE2 curriculum support staff could assist. Teachers were also asked to briefly plan out the activities and goals that they

had in mind for the next week. Goal planning served two purposes: (1) the GE2 staff could provide resources based on teachers' goals to support implementation, and (2) teachers could take a moment to consciously think about ideas for the next week to promote stronger implementation and to ensure that key milestones and curricular activities were accomplished.

After teachers completed their weekly log journaling each Friday, GE2 curriculum staff reviewed any requests for support and subsequently developed or provided resources to teachers based on the requests. The teacher journaling feature was implemented using Google Forms on a password-protected website for teachers. A screenshot of the weekly teacher log web form is provided in Figure 8.

Teacher Log[L]



GE2 Teacher Log

Please respond to the following questions for your work with the GlobalEd 2 curriculum this week. Your responses only need to be 2-4 sentences long.

Scroll down the form with the scroll bar or mouse until you see the "submit" button at the bottom.

* Required

Your name: *

Your answer

Location *

Are you from Connecticut or Illinois?

Connecticut

Illinois

Date of Log Entry *

Enter the week for which you are making this entry

Choose

Last Week

Did you conduct any GE2-related activities this week? *

Figure 8. Teacher log screenshot

5. *Weekly email bulletins*. Each week, teachers received an email bulletin with updates from the GE2 curriculum support staff. Updates included upcoming curricular deadlines pertaining to the GE2 negotiations simulation in which students were participating, suggested curricular resources (e.g., lesson plans, graphic organizers), video podcasts from content-area experts on topics with which students were discussing in the simulation, and updates for teachers on how well the simulation was proceeding. Also provided in the bulletin were any curricular resources that were developed by the GE2 curricular support team for teachers in response to the needs, issues, or challenges expressed by teachers in the previous week's teacher log. As emails were available in an HTML format, multiple URL links to teacher resources were persistently available in a navigation bar at the header and footer of the email. These links included direct navigation to teacher curriculum guide, lesson plans, previous bulletins, curricular calendar, and a contact page for staff support.

The weekly news bulletin was implemented in the Mailchimp email delivery software (www.mailchimp.com), which provides capacity to send HTML-based emails with images, hyperlinks, and structural formatting. In addition, Mailchimp provides a suite of analytic and email use log statistics, which are used in this dissertation. Figure 9 illustrates a sample weekly email bulletin, which demonstrates the structural and formatting functionality of HTML emails.

Figure 9. Screenshot of sample weekly email bulletin

3.2 Participants

A total of 41 middle school social studies teachers who were new to implementing the GE2 curriculum participated in a randomized field trial that investigated the efficacy of the GE2 curriculum over a one-semester period. Sampling was purposive by location, as it provided a rough approximation of the makeup of urban and suburban schools in the United States. Teachers were evenly recruited based on two locations in the United States, with the two locations representing urban and suburban school districts. To this end, approximately one-half of the participants consisted of teachers in a large, urban school district in the Midwest. The other portion consisted of teachers in suburban school districts in one Northeastern state.

As a part of the field trial, teachers implemented the GE2 curriculum for one semester in one social studies class at their respective schools. In this efficacy trial, data were collected for both the students receiving the GE2 curriculum and for an additional class of students in which the teacher did not use the GE2 curriculum, which represented a control condition of "teacher normal educational practice" (NEP). For this dissertation, only the data from the class in which the GE2 curriculum was implemented will be used. The NEP class data is not considered in this dissertation, as the GE2PD did not directly support curriculum implementation in the NEP class condition and would thus be inapplicable to an investigation of oTPD efficacy.

Teachers were required to have completed the up-front GE2PD component (e.g., all of the instructional modules) before they were permitted to implement the GE2 curriculum and participate in the ongoing component of the GE2PD. Every teacher that implemented the GE2 curriculum was strongly encouraged to participate in all aspects and activities of the GE2PD to the best of their ability, as it served to support teachers' continual curriculum implementation. However, participation was voluntary, and teachers could choose to participate at any level they desired. Teachers received a monetary stipend for their participation in the GE2PD while they implemented the GE2 curriculum.

In addition to teachers, the students in each of the participant teachers' classes engaged with in the GE2 curriculum that the teachers implemented in conjunction with the teachers' participation in the GE2PD. By extension, these students were also expected to benefit from the GE2PD, at least indirectly. Thus, these students are considered as participants in this study as well. 773 middle school social studies students participated in the GE2 curriculum at the time of the teachers' participation in the GE2PD and completed assessments as part of their GE2 curricular experience.

3.3 Data Sources and Data Processing

This study was conducted using secondary sources from unobtrusively collected digital server log data collected during a previous implementation of the GE2PD intervention. A substantial amount of preliminary data processing was necessary for the completion of this study, however.

3.3.1 Measuring oTPD Participation to Investigate the Efficacy of Individual oTPD Features

As discussed in Chapter 2, scholars have repeatedly found that it is increasingly insufficient for an oTPD effectiveness study to simply indicate whether teachers participated in a PD program as a single measure or experimental condition (e.g., participated in PD, did not participate in PD). Studies of this sort are especially insufficient if a PD program involves open-ended or customizable activity, such as those in oTPD programs. Online interactivity of an oTPD program afford teachers a range of flexibility in how they participate within the program and express themselves. Thus, measures with a high degree of resolution are increasingly necessary.

PD efficacy studies could examine the contribution of each feature to inform about the effects of the varied range and types of behaviors that teachers can exhibit in a PD and how PD behaviors ultimately contribute to teacher and student outcomes. To this effect, scholars have suggested the need for additional rigor in PD efficacy studies by including feature-level analyses in both observational and experimental studies (Hochberg & Desimone, 2010; Wayne et al., 2008). In their review of PD efficacy study methodology, Wayne and colleagues (2008) also suggest that the degree to which each feature in a PD program is used should be identified to account for the relative contribution of each feature as part of a whole PD program. As a result, high-resolution participation measures at the feature level are timely and address a substantial need to capture differences in the types and levels of participation to account for the degree to which the oTPD intervention was used by participants.

For this study, a feature-level analysis of the GE2PD oTPD was performed. As it was an oTPD intervention, web server logs of each GE2PD feature were used to automatically record participant behaviors, such as any time a click was made by a participant within each feature. Although the log data structure for each feature varied slightly based on the type of interaction afforded by each feature, the web logs in this study typically each recorded a timestamp of each click, a numeric identifier of the specific user who made the click, and a URL or unique identifier of what item was clicked (e.g., an image, a link).

In summary, the server logs specified what was done by each user and when. To be used for study, each of the server log data sources will require processing to compute variables that can provide additional information on varying levels of participation and effort within each oTPD feature. Because each feature in the GE2PD used its own data source logs, each GE2PD feature will require separate data processing procedures.

3.3.2 Data Sources and Variable Computation

To perform a "feature-level" oTPD efficacy evaluation (Hochberg & Desimone, 2010; Wayne et al., 2008), teacher participation with each GE2PD design feature will be represented by a participation variable for each respective design feature. Participation variables will be computed by the author based on the expected level of effort of each participant on a given feature, as can be observed from server log files. Each participation variable will be constructed from server logs in a way that the level of effort can be validly inferred and reliably measured. As a result, each participation variable will ultimately reflect different types of effort, as it is reasonable to expect that participation with one feature is characteristically different than others.

Variables in the study will be computed as interval-level data, reflecting meaningful, measurable differences between values as reflected in the server logs (e.g., number of pageviews, frequency of posts, duration). Alternatively, in any case where participation with design features is not readily measured on an interval scale, variables were computed as ordinal, rank-ordered progressions of level of effort (e.g., the teachers' written activities in the up-front PD segment). Thus, all of the participation variables will reflect the degree to which participants used each feature and were exposed to the overall GE2PD intervention's key elements.

For each design feature of the GE2PD, a server log file was maintained that actively recorded every system-level behavior of individual teachers as they used the feature. System-level log events for this dissertation included a numeric ID of the user, a record that a click was performed on a valid element (e.g., a link, a button), what resource was activated (e.g., the page a user went to), and a timestamp of when the action was completed.

In summary, data processing resulted in five participation variables, one for each oTPD feature in the GE2PD. Additionally, one variable related to teacher adherence to curricular tasks was developed to investigate the relationships between oTPD participation and subsequent teacher practice in the classroom. The practice-based variable of curriculum adherence was derived from the simulation online learning environment used by students during the GE2 curriculum.

Student outcomes are also considered in this study. Student-level achievement will be represented by one variable for argumentative writing skills, which was the primary learning outcome of the curriculum. This distal student outcome variable consists of a scale that is each composed of multiple items collected from a pre-post instrument delivered to students during the implementation of the GE2 curriculum during the same semester as the teachers' participation in the GE2PD. The scale has been used in previous studies and show strong internal reliability (alpha > 0.90) (Brown et al., 2016; Lawless et al., 2018; Riel, Lawless, Brown, & Lynn, 2015). Generated from pre-post instruments, the student writing outcome measure contains both pre and post values for each student, representing student levels argumentative writing skills before and after the GE2 curriculum implementation.

As student outcomes are the endpoint of the analyses for this dissertation, the student dataset are composed of student-level grain size data. To account for teacher-level information in relation to distal student outcomes, such as the amount of teacher participation with each oTPD design feature, teacher-level data are nested within each student-level case, representative of the teacher-level variable scores for that student's teacher. Each data row represented a single student, with data on the specific student's teacher included. Thus, some columns in the data structure indicated a particular student's personal achievement scores, and some columns will represent the values of variables for a student's teacher. This processing step of nesting teacher values within student-level data was necessary for the multi-level statistical models that are used in the analysis portion of this study.

Each of the variables that are used in this dissertation are further discussed in the sections below. For each section, a detailed description of the variable's definition, its data source, and the procedure that was used to calculate it are provided. Table VII provides a summary of each data source that is used in this study. Similarly, Table VIII provides a description of each of the variables used in this dissertation.

TABLE VII

SUMMARY OF DATA SOURCES USED IN THIS STUDY

Name	**Data Source / Description**
PD Module Video Watching	Moodle pageview logs; duration calculated via pageview timestamp comparison
PD Module Writing Tasks	Moodle pageview digital server logs; teacher written artifacts
PD Live Simulation	Live simulation interaction digital server logs (ICONS system)
PD Teacher Log	Written teacher logs collected during the implementation period; collected via Google Forms
PD Email Bulletin	MailChimp interaction tracking logs (tracking pixels and unique URLs)
Teacher Curriculum Implementation Adherence	Digital server logs from the online simulation environment during implementation
Student Written Scientific Argumentation Skills	Pre-post instrument administered to students at beginning and conclusion of curriculum implementation

TABLE VIII

SUMMARY OF VARIABLES USED IN THIS STUDY

Name	Concept Measured
Video Watching	Total number of seconds of unique video watched; re-computed as a percentage of total unique video watched as ratio of available unique video for ease of interpretation.
Writing Projects	Summed score of 7 writing projects; scores based on rubrics that analyzed whether expected elements were included in the written project (i.e., expected level of effort achieved)
Live Mini-Simulation	Sum of the number of posts within the scheduled live mini-simulation by a teacher
On-Time Teacher Log Completion	Sum of the number of weekly teacher logs that teachers completed on time
Email Bulletin Use	Sum of the number of opens (max=1) and number of clicks (max=2) each week with the email bulletin. All weeks summed to one single score.
Teacher Curriculum Implementation Adherence	Count of number of expected curricular events that a teacher completed within the implementation period.
Student Written Scientific Argumentation Skills	Measures skill in using claim-evidence-reasoning skills within a given essay.

Up-Front Component

3.3.2.1 <u>Module Video Watch Duration</u>

Each of the 7 instructional modules in the up-front PD included a number of videos that were delivered to teachers via the Moodle learning management system and were hosted using the Vimeo video hosting service. The level of effort for video watching will be measured as the total elapsed watch time or duration of videos watched during the up-front PD.

As the Vimeo video hosting service does not report the actual video streaming duration in which a video was playing in an active browser window, the video watch duration for each participant will be alternatively measured using the method from a previous study by the author (Riel, Lawless, & Brown, 2017b). This measurement method can be used when no direct "watch time" data are collected of when video is actively playing in the web browser (such as the case with embedded streaming services, such as Vimeo or YouTube). Instead, the method is used to infer the participant video watch time by comparing subsequent pageviews of video-dominant pages within a single session. In the case of the GE2PD, videos were served on module pages in which the video was the only content. Thus, it could be inferred that if a participant viewed a video page for any length of time before clicking to another page, the user likely watched the video.

This measurement method infers watch time by considering the timestamps of pageview server log entries, in which two consecutive pageviews can be compared and the difference in time calculated to determine elapsed time. Additionally, the method allows for the removal of cases in which the difference in time between pages is either low or too high. A video-based page was counted for elapsed time if its duration is 20 seconds or more, as to avoid including pageviews that were most likely navigational movements on the website and the participant probably did not engage with the video. In addition, durations on video pages that are higher than 3600 seconds (i.e., 30 minutes) were also disregarded, which likely indicate that the participant abandoned the video page and did not watch the video for that long of a duration.

The use of this measurement approach resulted in a single watch duration variable for each participant, which was be computed as the sum of the watch duration for all videos that a participant watched in the up-front PD.

3.3.2.2 Module Written Activity Completion

For each of the modules, a written project served as the culminating activity for each module. Seven written projects in total were completed by each participant. This written project was intended to be an item that the teacher could immediately use in their classroom upon completing the PD, such as lesson plans, assessment plans, rubrics, and technology plans. As with any project that requires participants to generate an artifact, the level of effort can vary between projects for a single participant, as well as between participants.

For each of the seven projects completed by each participant, a list of expected elements that were to be included in the written document was provided to participants. The written activity portion of the GE2PD was unique in that it consisted of writing activities to be performed by participants, but also included meta-level discussions about the writing activities among participants and support staff. Because of this, it was best during data processing to identify any various types of effort that emerged within the activity and score participants' level of effort based on the expected elements list through a qualitative analysis process. This approach subsequently promotes a higher resolution of data and enables the research to capture different types of effort that might be exhibited during this activity that were not determined at the start of the activity via the list of expected elements within writing activities.

The rubrics for each written task were determined during a first round of coding of the written projects in consultation with the list of expected elements that were to be included within each written task. This part of the data preparation was chosen as it was intended to "stay close" to the data to identify types of effort that were evidenced by participants. This approach allowed for each written work to be examined along any emergent dimensions that appeared during the exploratory first round of open coding of both expected and non-expected present elements within the writing. Such non-expected elements that appear in the writing could be sources of information that exhibit further variance in level of effort, such as length of writing, whether the given objectives for the writing task were completed, and whether the participant interacted with other participants on their writing tasks. Because there was potential for emergent activity via the written projects, this approach provided a higher level of resolution of information regarding participants' level of effort on the writing tasks in comparison to simply recording whether participants completed a writing task or not.

Although the data for the writing activities in this study are ultimately represented quantitatively, a qualitative scoring process was used to determine values in the rubrics. To accomplish this task, the two rounds of basic qualitative inductive analysis process generated the scoring rubrics for each written activity (Merriam, 2009; Thomas, 2006). A basic inductive analysis is appropriate for this purpose, as it provides a structured approach for extracting categories while prioritizing the actual language of participants. This allowed for categories to inductively emerge within the context they are found, allowing for higher level of construct validity, and then be appropriately collapsed when reducing the data (Thomas, 2006).

To begin the process of generating the composite written activity variable, I will conducted a first round of qualitative analysis on each written activity to generate the rubrics. This first round of coding involved roughly linking the list of expected elements to teachers' written work to a sample of each written activity (e.g., each of the seven different activities teachers were asked to complete). I reviewed each written work product to identify the presence of any of the expected elements on the pre-established list of items that were to be included in the written work, and the structural forms that these expected elements commonly took. In addition to coding specific areas in which the expected elements appeared within written work and documenting the various forms each type took, I also conducted open coding on areas of the texts that did not directly map to the list of expected elements. I used open descriptive codes to identify and capture notes regarding these "unexpected" areas within a document. The first round of coding accounted for general locations in a given writing artifact where expected elements are present, as well as identified areas for further analysis in round 2 to conceptually connect any additional unexpected elements to the list of expected elements, and, by extension, the observed level of work.

In the second round of coding, I revisited the expected and unexpected areas that were identified in the first round of coding. Using a thematic analysis approach to infer broader themes from specific examples, I iteratively connected and related themes of both the expected and the "extra" elements that were observed from the open descriptive codes that I made in the first round with the original list of expected elements, and to reduce the broader set of categories into smaller subsets of rank-ordered themes. The purpose of this step was to allow for the rubrics to capture varying levels of effort that are indeed conceptually and logically higher than the expected level of effort itself, and as a result, have any higher levels of effort reflected in the ordinal scale (as indicated by the baseline list of expectations). The resulting rubrics were then used for scoring each of the written projects by each teacher. The final versions of each scoring rubric are provided in Appendix A.

After the rubrics were generated, they were applied to the seven writing activities for each teacher in a third round of coding on the data. This third round resulted in a numeric score for each written task for each teacher.

Indeed, the approach described above for inferring level of effort from written work does not capture the entire range of how a participant might expend effort on a task. Multiple other aspects of effort are not directly observable, such as the amount of time it took to write the assignment, research the assignment, However, because these data are not readily available, the inferred level of effort provide a good baseline measure for researchers seeking to investigate level of participation via written artifacts. It is also important to note that the data transformations for teacher writing activities do not evaluate the *quality* or *correctness* of the written work. Instead, as the variable simply attempts to identify the exhibited level of effort using the expected level of participation in the written activities as a baseline.

The composite teacher written activity participation variable is composed of the sum of the presence of expected items within each of the seven individual activities.

3.3.2.3 <u>"Live Mini-Simulation" Participation</u>

To culminate the up-front portion of the GE2PD, teachers participated in a one-day live mini-simulation using the technologies and interactive environment used by the GlobalEd 2 curriculum. The mini-simulation was conducted over four hours on one day, and mirrored the same functionality, technology, and activities with which the teachers' students would engage in the upcoming fall implementation, giving teachers direct experience with these technologies.

Participation in the live simulation was structurally different than other tasks in the GE2PD, in that activities were open-ended and successive tasks did not necessarily logically build on each other like the other variables discussed in this section. Because this task was open-ended, and the number and length of interactions are recorded, the variable for live sim participation was computed as an interval-level measure based on the number of times a participant posted in the live sim. Because the live simulation operates solely on posts from participants, this measure is an accurate representation of the level of effort that the participant exhibited during the synchronous live simulation.

Ongoing Component - Weekly Responsive Online Professional Development

3.3.2.4 <u>Teacher Log Completion</u>

Each week during the PD, teachers had the opportunity to complete a form-based teaching log journal. The log was designed to provide PD participants with the chance to reflect on their previous week's teaching and give direct feedback to the GE2PD staff about PD opportunities that participants desired.

Completion of the teacher log consistently over time was an emphasized aspect of participation. Thus, the variable for teacher log completion represents teachers' ongoing effort to consistently reflect on practice by completing the teacher log on time each week. The teacher log variable was constructed using the approach for measuring weekly teacher log use that was piloted in Riel et al (2015), with each teacher that completed an on-time log receiving a score for the given week. This approach at the least provides no score for no submitted logs on a given week or a score of one if submitted on time.

3.3.2.5 <u>Weekly Email Bulletins Use</u>

To calculate a teacher's overall level of effort with weekly email bulletins, this dissertation will use the method that was piloted in Riel et al (2015). In this way, teachers' participation with the weekly e-bulletin was computed based on the degree to which teachers interacted with a bulletin each week, which was subsequently totaled over all weeks for each participant into a combined score. In terms of level of effort, a participant has opportunities to use the email bulletin in different ways, which can be measured on an interval level scale based on the number of clicks performed. Emails were delivered using the Mailchimp email system, which included a suite of interaction tracking tools such as unique tracking URLs and image pixels. The Mailchimp system was able to determine whether a specific participant opened the email, when an email was opened, whether links were clicked, and which links were clicked on.

The level of participation with each week's bulletin will calculated and then all weeks' participation is summed into a single value. As to not allow any given week to overwhelm the measure with an abnormally large number of clicks by a single teacher, and thus decreasing the meaningful information within the variable, the maximum score for any given week was 3. This represents a score in which an email was opened (+1 point) and multiple links were clicked (+2 points for at least two links clicked). There were 14 weeks of the GE2PD, and within each week one email bulletin was delivered to teachers. Thus, the level of participation for this feature will consider whether an email was opened at all as well as how many links were clicked within the email.

3.3.2.6 Teacher Practice: Adherence to Curriculum

As discussed in Section 3.1.a., teacher adherence to the GE2 curricular activities is the primary indicator of teacher practice that was investigated in this study, which was the primary proximal goal of the GE2PD intervention. This study developed a variable to measure the degree to which a teacher performed the expected tasks in the GE2 curriculum. The primary source of data for this information will be via server logs from the online curricular environment in which teachers' students interacted, performed various tasks, and completed curricular activities.

A full list of expected curricular implementation tasks were made available to teachers throughout the semester of their implementation, which includes having students post regularly in the online interactive environment and encouraging student participation in the scheduled live conferences. Table IX summarizes the curriculum implementation tasks that were expected of GE2 teachers.

TABLE IX

INVENTORY OF EXPECTED GE2 CURRICULAR IMPLEMENTATION TASKS: ADHERENCE

Expected Task
Students' opening statements posted on time, one per issue area group (1 opening statement for each group, 4 = 4 possible points)
Each classroom send messages weekly (6 weeks = 6 possible points)
Participate in the live conferences when scheduled (4 groups, 2 conferences for each group = 8 possible points)
Complete and post a closing statement (1 closing statement for each group, 4 groups = 4 possible points)
Total possible adherence points = 22

The server logs for the online environment were evaluated to see if each expected activity was completed in the system. Completion of activities within the online system reflected a teacher's implementation and subsequent guidance of their students in the completion of activities. As the server logs provide indicators as to whether these activities were present or not, this variable will be composed of a tally of curricular events that were completed by each teacher over the multi-week period. Adherence will be measured by assigning a value of 1 for the presence of each curricular event completion, and conversely, 0 for lack of presence in the logs. To process the composite adherence score for each teacher, the values for each curricular activity were summed for each teacher, representing overall adherence to expected implementation tasks.

3.3.2.7 Student Achievement: Argumentative Essay Instruments

Two instruments representing written scientific argumentation were administered to students at both the beginning and conclusion of the GE2 curriculum implementation period (i.e., a pre-post design). Each assessment was identical at both the pre- and post-testing period. The written scientific argumentation was composed of a single essay that was scored for demonstration of a range of argumentation skills and presence of specific argumentation elements (e.g., claims, evidence, reasoning) by two coders using a predetermined coding rubric. Students were scored on their quality of use of claim-evidence-reasoning skills in their level of written argumentation on a scale of 0 to 3 for each element present: the presence of a clear *claim* (max 2 points), the use of data-based *evidence* and citations (max 3 points), and the use of logical *reasoning* to connect the claim to the evidence and show why the claim should be supported (max 2 points). The instrument's minimum score for a student was a 0 (for no argumentative elements present within the essay) and the maximum was 7 (all argumentative elements are present at their highest quality). However, no student scored a 7, as 6 was the maximum score achieved.

Disagreements in coding were resolved via third coder and interrater reliability was over 80%. The full version of the assessment as administered is included in Appendix B, which was identical between pre and post administration. Appendix C provides a copy of the scoring rubric used to generate the original dataset representing student written argumentation skills. However, for this dissertation, this was a pre-existing dataset and no additional scoring was performed on student data.

The data from student assessments contain multiple items that have been previously coded and analyzed in prior studies, although not in the context proposed in this study (see e.g., Brown et al., 2016; Lawless et al., 2018; Riel, Lawless, Brown, & Lynn, 2015). This study makes secondary use of this data set to investigate the indirect efficacy of the GE2PD program on distal student achievement.

3.4 Study Approaches And Conduct of Analyses

3.4.1 Analysis 1 — Descriptive Statistics

In the first step of analysis, descriptive statistics were computed and presented for each of the variables in the study. Descriptive statistics will include the number of cases, mean, standard deviation, minimum, maximum, and range. These statistics provided evidence as to whether there is substantial levels of participation with the GE2PD design features, as well as determining the degree of variation within each of the design features. The variation among variables are necessary to identify, as they provide initial indicators as to whether a feature was used at all by participants.

In addition to descriptive accounts, correlations between the six variables representing GE2PD design features were analyzed using Pearson's R. This provided evidence for whether teachers tended to spend effort on all features of the GE2PD at similar rates, or, alternatively, if the activities are relatively independent of each other. This is also useful for evaluating the data for whether assumptions are met for general regression and hierarchical linear models that were used for Hypotheses 4-7 in assessing for potential multicollinearity of variables and their potential undue impact on models.

In Analysis 1, the following study hypotheses were tested:

H1 — In aggregate, teachers exhibited substantial levels of participation in each of the GE2PD individual design features.

H2 — Each of the GE2PD design features exhibited substantial variation in the level of participation between teachers.

H3 — There are no large correlations of teacher participation levels between GE2PD design features (but low to moderate correlations are expected).

3.4.2 Analysis 2 — Regression Modeling to Investigate Teacher-Level Outcomes

To investigate the effects of teacher participation with PD features on teachers' practice (as measured by implementation adherence fidelity), an ordinary least-squares regression approach was conducted, with *adherence* as the dependent variable and each of the PD feature participation measures as independent variables. PD features were sorted into the up-front and ongoing segments in this analysis to see which features were most effective at predicting teachers' level of curriculum adherence. Before analysis, the independent variables were examined for severe multicollinearity in Step 1 in the section above, which was ultimately not observed. Both regression analyses were conducted using the open-source PSPP statistical software package.

The regression equation for predicting adherence from up-front PD features is provided in Equation 1, and the regression equation for predicting adherence from ongoing PD features is provided in Equation 2. In both cases, Y_i represents the dependent measure *adherence* for teacher *i*. For the up-front PD features in Equation 1, WRIT represents teachers' writing project scores, VID represents teachers' amount of up-front course video that was watched, and MINISIM represents teachers' level of mini-simulation participation. For the ongoing PD features analyzed in Equation 2, EMAIL represents teacher use of weekly email bulletins and TLOG represents the level of teachers' on-time completion of weekly teacher logs. ε_i represents the error term for both equations.

$$Y_i = \beta_0 + \beta_{WRIT}X_i + \beta_{VID}X_i + \beta_{MINISIM}X_i + \varepsilon_i \quad \text{(Equation 1)}$$

WRIT = Teacher Writing Project Score
VID = Teacher Amount of Up-Front Course Video Watched
MINISIM = Teacher Mini Simulation Participation

$$Y_i = \beta_0 + \beta_{EMAIL}X_i + \beta_{TLOG}X_i + \varepsilon_i \quad \text{(Equation 2)}$$

EMAIL = Teacher Weekly Email Score
TLOG = Weekly Teacher Log Completion Score

In Analysis 2, Hypothesis 4 was tested:

H4 — Each of the design features in both segments of the GE2PD (i.e., upfront and ongoing) had a positive direct effect on teacher curriculum implementation adherence.

3.4.3 Analysis 3 — Hierarchical Linear Modeling to Investigate Student-Level Outcomes

In the final step of analysis for this dissertation, a mixed-model, or hierarchical linear model (HLM) approach was used to investigate whether teacher-level PD participation and curriculum adherence variables predict student level outcomes. Because of the nested nature of the data (i.e., student-level data nested within groups of teachers), a mixed-model approach such as HLM is appropriate to provide robust predictive evidence of the impact of independent variables that are nested in nature (Raudenbush & Bryk, 2002). Two levels are sufficient for this study, as students (level 1) are nested within teachers' classrooms (level 2).

The HLM analyses were conducted using the R statistical software package with the *lme4* library to conduct the mixed-effects linear modeling within R (Bates, Mächler. Bolker, & Walker, 2015). Within R, the libraries *lmerTest, languageR, tidyr,* and *dplyr* were also used. This analysis employed random effects, as well as the restricted maximum likelihood (REML) approach to make the variance estimates of the components in the model. In short, REML is a family of likelihood functions that provide estimates of variance components within HLM models that contain random effects (i.e., no fixed effects) and ultimately converge on an estimated solution to the model after multiple iterations (Gurka, 2006).

In the HLM analyses, student post-assessment writing scores served as the dependent variable. This assessment was taken at the conclusion of the GlobalEd curricular intervention. Student's pre-assessment scores taken before GlobalEd are also accounted for as independent predictors in the model. Because the writing argumentation skills measure does not have a meaningful zero point (i.e., no student scored a zero on the scale), the pre- and post-writing scale scores were centered around the grand mean at both the student and teacher levels. Centering values around the grand mean within HLM is standard practice and allows for meaningful coefficients to be output by the HLM approach and clearer interpretation of results by research.

<u>Level 1 equation:</u> (Equation 3)

$Y_{ij} = \beta_{0j} + \beta_{1j}*(SC\_PRE)_{ij} + e_{ij}$

<u>Level 2 equation:</u>

$\beta_{0j} = \gamma_{00} + \gamma_{01}*(TWRIT)_j + \gamma_{02}*(TVID)_j + \gamma_{03}*(TMINISIM)_j + \gamma_{04}*(TEMAIL)_j + \gamma_{05}*(TLOG)_j + \gamma_{06}*(TC\_PRE)_j + \upsilon_{0j}$

<u>Expanded model:</u>

$Y_{ij} = \gamma_{00} + \gamma_{01}*(TWRIT)_j + \gamma_{02}*(TVID)_j + \gamma_{03}*(TMINISIM)_j + \gamma_{04}*(TEMAIL)_j + \gamma_{05}*(TLOG)_j + \gamma_{06}*(TC\_PRE)_j + \gamma_{10}*(SC\_PRE)_{ij} + \upsilon_{0j} + e_{ij}$

Y_{ij} = Post-assessment writing score (student) for student *i* within classroom *j* (i.e., teacher)
e, υ = Random effects terms
TWRIT = Teacher writing score, within student-level
TVID = Teacher video watching score, within student-level
TMINISIM = Teacher mini-simulation score, within student-level
TEMAIL = Teacher email score, within student-level
TLOG = Teacher log score, within student-level
TC_PRE = Teacher-centered nested student pre-writing score, grand mean centered
SC_PRE = Student-centered pre-writing score, grand mean centered

Equation 3 specifies the model in which student writing (i.e., post-assessment score) is predicted by nested teacher-level PD participation variables, while accounting for students' pre-assessment scores. In the equation in the first level, Y_{ij} represents the dependent variable of post-assessment writing score for student *i* within the classroom of teacher *j*. β_{0j} represents teacher *j* and the second level of the model. SC_PRE_{ij} is the student pre-writing assessment score for student *i* for teacher *j*, centered around the grand mean. e_{ij} represents the error term or random effects for the student-level portion of the equation for student *i* for teacher *j*.

In the second level, the teacher-level PD participation variables are all represented with increasing indices: TWRIT (teacher writing projects), TVID (teacher video watching amount), TMINISIM (teacher mini-simulation participation), TEMAIL (teacher weekly email bulletin use), and TLOG (weekly teacher log completion). TC_PRE is the student-level pre-assessment score for the entirety of the teacher's classroom, centered around the grand mean. υ_{0j} represents the random effects for teacher *j*. An expanded version of the entire equation is also provided in Equation 3.

Similarly, Equation 4 specifies the model in which student writing (i.e., post-assessment score) is predicted by the nested teacher-level curriculum adherence score, while accounting for students' pre-assessment scores. The terms in this equation are similar to Equation 3, with the exception of the addition of (ADH)*j*, which represents the curriculum adherence of any given teacher *j*.

Level 1 equation: (Equation 4)

$$Y_{ij} = \beta_{0j} + \beta_{1j}*(SC\_PRE)_{ij} + e_{ij}$$

Level 2 equation:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}*(ADH)_j + \gamma_{02}*(TC\_PRE)_j + \upsilon_{0j}$$

Expanded model:

$$Y_{ij} = \gamma_{00} + \gamma_{01}*(ADH)_j + \gamma_{02}*(TC\_PRE)_j + \gamma_{10}*(SC\_PRE)_{ij} + \upsilon_{0j} + e_{ij}$$

Y_{ij} = Post-assessment writing score (student) for student *i* within classroom *j* (i.e., teacher)
e, υ = Random effects terms
ADH = Teacher adherence score, within teacher level
TC_PRE = Teacher-centered nested student pre-writing score, grand mean centered
SC_PRE = Student-centered pre-writing score, grand mean centered

Because of the nature of pre-post instrumentation and requiring two timepoints of data collection with students in authentic school settings, it is not uncommon for students to fail to provide data for one or both of the instruments because of absence from school or declining to participate in the research. As a result, any missing cell within a case was handled by case-wise removal during the HLM analyses. This resulted in a total of 659 full cases in which a student completed both a pre and post instrument.

To conclude the dissertation, the final hypotheses were tested in Analysis 3:

H5 — Each of the design features of the up-front portion of the GE2PD had a positive indirect effect on desired distal student achievement, measured as scientific argumentative writing.

H6 — Each of the design features of the ongoing portion of the GE2PD had a positive indirect effect on desired distal student achievement measured as scientific argumentative writing.

H7 — Teacher curriculum implementation adherence had a direct effect on distal student achievement in students' scientific argumentative writing achievement.

CHAPTER 4: RESULTS

4.1 Analysis 1 — Descriptive Statistics

Descriptive statistics provide evidence on the range of participation with each of the PD features and how teachers performed relative to each other.

To test Hypotheses 1 and 2, descriptive statistics are consulted to identify the degree to which each of the GE2PD features were used by teachers in comparison to the maximum level of participation that was possible based on how the variable was measured. Table X provides a summary of descriptive statistics for each of the variables used in the study.

TABLE X

SUMMARY OF DESCRIPTIVE STATISTICS FOR VARIABLES

Variable	Mean	St. Dev.	Min.	Max.	Range
Up-front PD					
Writing activities	48.61	12.24	10	64	54
Video watching (as % of total available video watched)	71	27	0	100	100
Mini-simulation participation	22.29	11.09	0	41	41
Ongoing PD					
Weekly email bulletin interactions	16.73	8.60	2	36	34
Teacher log on-time completion	8.07	3.42	0	13	13
Other variables					
Teacher curriculum adherence	9	2.72	2	15	13
Student pre-assessment writing	2.85	1.18	0	6	6
Student post-assessment writing	3.20	1.19	0	7	7

Hypothesis 1 tests whether there was a substantial level of participation for each of the design features. This hypothesis can be supported, as evidenced by the relatively high means for each of the five design feature variables in comparison to zero, as illustrated in Table X. A score of 0 is possible on each of the PD participation variables, making higher relative means evidence of substantial use of the feature. However, it should be noted that there were some cases in which at least some teachers did not participate with a feature, as indicated by a zero score on the minimum of the variable. For instance, for the video watching variable, teachers watched on average 71% of the total video that was available in the up-front course. In this situation, teachers could have chosen not to watch any video (as was the case for at least one teacher, as evidenced by the minimum score of 0 on this variable). The min-max range on all of the five variables is substantial in each case, allowing Hypothesis 1 to be supported that each of the PD features were used widely by most teachers.

Hypothesis 2 tests whether there was a substantial variation in teacher participation for design features rather than participation being constant. This is important to determine, as constant values related to participation in a PD feature indicate that an element is either required or not noteworthy in terms of design variance or flexibility in the feature's use. In Table X, each PD design variable exhibits a substantial standard deviation in comparison to the range of the value, indicating that there was variation between teachers in their levels of participation with each of the GE2PD design features.

One particularly effective illustrative example exists in this analysis to demonstrate this point. Video watching during the up-front PD is represented by a variable that is measured in units of the percent of total available video that was watched, or whether all of the course videos were watched in their entirety by participants. In computing this variable, only a finite number of *unique* video seconds could be watched by teachers, and thus asking the question of whether teachers watched all of the videos in their entirety. The range of this variable also happened to be 100, indicating that at least one teacher scored 0 (i.e., 0 percent of video watched; the minimum amount), and at least one teacher scored 100 (i.e., 100 percent of available video was watched; the maximum amount). As such, being a percentage value, the standard deviation is relatively simple to interpret.

The standard deviation of 27 for the video watching variable represents a sizeable variation among teachers due to the range that was centered between 0 and 100. Within either side of the mean of 71, one standard deviation on both sides consisted of scores of 44 to 98 for the video variable. By definition, one standard deviation on both sides of the mean represents approximately 68% of the teachers within the observed distribution. which is a substantial amount of variation.

This same result of a sizeable, but not too large standard deviation is also observed for the other four participation variables. Differences or fluctuation in the levels of participation potentially signal flexibility, adaptation, and varying patterns of use among teachers in comparison to a constant participation rate, and thus presents a research interest as to what perhaps some of these ways of using the feature are (although this trajectory is beyond the scope of this dissertation). The presence of variation is then important for designers and researchers to track in their designs as it provides signals for whether usage is exhibiting multiple patterns.

As each of the PD participation variables exhibited a moderate standard deviation, especially in comparison to the range of each variable, Hypothesis 2 can be supported.

To test Hypothesis 3, a Pearson's *r* analysis provides evidence of the level of correlation between each of the PD participation variables. Table XI provides a summary of each of the correlation coefficients between variables, as well as the measure of statistical significance between each relationship.

TABLE XI

CORRELATIONS BETWEEN GE2PD PARTICIPATION VARIABLES
(N = 41 TEACHERS)

	Writing Activities	**Video Watching**	**Mini-Simulation**	**Email Bulletin**	**Teacher Log**
Writing Activities					
Video Watching	**.70** Sig .< 001				
Mini-Simulation	**.42** Sig .055	**.57** Sig .002			
Email Bulletin	**.43** Sig .002	**.42** Sig .002	**.27** Sig .055		
Teacher Log	**.55** Sig < .001	**.55** Sig <.001	**.51** Sig .< 001	**.60** Sig <.001	

As seen in Table XI, each of the five PD variables are moderately correlated with each other, as expected. In each of the cases except for two (email × mini-simulation and writing × mini-simulation), the observed significance levels were $p < .001$. For the other two cases, the significance levels were $p < 0.055$, which is only slightly over the typically accepted benchmark for significance and are closely approaching a significant value. A summary of the table concludes that all the variables had low or moderate correlation with each other (nothing greater than $r = .75$).

In the case of the relationship of video watching with writing activities, the highest correlation in comparison to other relationships was observed ($r = .70$). This is likely because of the proximity of the videos alongside the written activities in the up-front PD course. In the course, teachers watched videos, then completed a written activity for each module. As these two activities are tied to each module and happened in sequence with each other, they are more closely linked than the other PD participation variables. Because of this design consideration, this correlation should be expected.

The second-highest coefficient is between the teacher log and weekly email (r = .60). This is likely because completion of the weekly teacher log was partially dependent upon email bulletin delivery for some teachers by design. A link to the teacher log was included within the weekly email along with a gentle reminder for teachers to complete their log for the week. By design, the email encouraged participation with the teacher log and reminded teachers to complete it for the week when they received the email bulletin each Friday morning. Thus, this relationship was expected, and is useful to see that this link is present to provide some evidence for confirming that the intent for promoting teacher log completion via the email was effective. Indeed, many of the clicks in the weekly bulletin occurred when teachers were navigating to the teacher log web page via a weblink in the email.

As all the PD participation variables have low to moderate correlation with each other, Hypothesis 3 can be supported.

4.2 Analysis 2 — Regression Modeling to Investigate Teacher-Level Outcomes

Hypothesis 4 was tested with two regression models, each of which looked the dependent teacher outcome variable of curriculum adherence fidelity. In one model, the GE2PD features of the up-front course portion were considered as independent predictors, while in the second model, GE2PD features of the ongoing portion were considered as independent predictors. Table XII provides a summary of the first regression model results (up-front PD participation) and Table XIII summarizes the results of the second regression model (ongoing PD participation).

TABLE XII

REGRESSION RESULTS FOR UP-FRONT PD PREDICTING
TEACHER CURRICULUM ADHERENCE

	B	**Std. Error**	**Beta**	**t**	**Sig.**	**CI**
(Constant)	2.75	1.32	.00	2.09	.042	[.10, 5.40]
Video Watching	-.29	1.79	-.03	-.16	.874	[-3.89, 3.32]
Mini-Simulation Participation	.06	.03	.24	1.70	.095	[-.01, .13]
Writing Activities	.11	.04	.47	2.88	.006	[.03, .18]
Model Fit Statistics	R	R-Square	Adj. R-Square	Std. Error		
	.60	.35	.31	2.25		
ANOVA	F	Sig.				
	8.60	.000				

As summarized in Table XII regarding the up-front PD features as predictors of teacher adherence, the regression model fit was statistically significant [$F(3,47) = 8.60$, $p < .000$]. The model exhibited a sizeable adjusted r-square value of .31, signaling that 31% of the variance was explained by the variables in this model. However, only the writing activities variable predicted future teacher curriculum adherence at a significant level ($p = .006$). It is worth noting, however, that mini-simulation participation has a p-value that is approaching significance ($p = .095$), and thus signals that this design feature is also worth further study in future research. Although 41 teacher participants are a large sample size for a typical educational intervention, it remains relatively small to ensure a sizeable statistical power for identifying small effects.

TABLE XIII

REGRESSION RESULTS FOR ONGOING PD PREDICTING
TEACHER CURRICULUM ADHERENCE

	B	**Std. Error**	**Beta**	**t**	**Sig.**	**CI**
(Constant)	6.32	.94	.00	6.69	.000	[4.42, 8.21]
Teacher Log On-Time Completion	.32	.13	.41	2.49	.016	[.06, .59]
Weekly Email Bulletin Use	.00	.05	.01	.07	.947	[-.10, .11]
Model Fit Statistics	R	R-Square	Adj. R-Square	Std. Error		
	.41	.17	.14	2.52		
ANOVA	F	Sig.				
	4.98	.011				

Similar to the up-front PD regression analysis, the model fit of the regression model for the ongoing PD features as predictors of teacher adherence was statistically significant [F(2,48) = 4.98, p = .011]. As seen in Table XIII, however, this model exhibited a smaller adjusted R-square value of .14 in comparison to the model of the up-front PD features. This demonstrates that only 14% of the variance is explained in the model and that it has less predictive capacity in general in comparison to the up-front PD regression model, but still retains statistical significance.

Similar again to the up-front PD model, this model only had one predictor that demonstrated statistical significance: on-time teacher log completion ($p = .016$). In a similar vein as the up-front PD, this could most readily be explained because of the more intensive activity that is required to complete a teacher log in comparison to interacting with an email. In addition, email interaction can be completely missed on a given week by teachers, either by being ignored or due to any number of technical or personal issues may arise. Teacher logs, on the other hand, were designed to be purposefully reflective and required teachers to give thought to what they did the previous week and to plan the following week's activities. The evidence here shows that those who used the log by design (i.e., on-time submissions of the log) benefited the most in completing future curricular implementation tasks.

These results should not diminish the value of the email bulletin, however. Although it did not show statistical significance in this study, providing news and support, as well as an open line of communication is essential with teachers who are actively implementing a new curriculum and participating in ongoing PD. The direct effects on teacher practice of an email bulletin were not observed in this analysis, but that does not imply that communications and updates for teachers have no effect, either. In fact, the correlations performed in Analysis 2 revealed that the email and teacher log were correlated with each other to a moderate degree. As stated in that section, the email became a navigation point and reminder for teachers to complete their teacher log each week. Thus, the email news bulletin likely served many useful functions, but the instruments and measures used in this study may not have been sensitive enough to identify these effects (which is beyond the scope of this study to discern, as it was proposed and performed). But it is almost certainly the case that communications with teachers who are participating in ongoing PD are not just useful but are indeed required.

4.3 Analysis 3 — Hierarchical Linear Modeling to Investigate Student-Level Outcomes

In the final analysis of this dissertation, two hierarchical models were fit to student-level data to investigate the effects of the GE2PD on student achievement.

For the first model, each of the GE2PD participation variables were input as independent predictors at the teacher level, within which student-level data were nested. This analysis predicted whether any of the GE2PD variables had a predictive result on student-level outcomes (i.e., scientific writing skills). The results highlighted in Table XIV reveal the results of this first HLM model in its first iteration before any independent variables were removed in attempt to optimize the model. Model statistics were also computed and reported for the RMEL approach to providing maximum likelihood estimates and converging within the model (Bates, Mächler. Bolker, & Walker, 2015; Gurka, 2006).

TABLE XIV

HIERARCHICAL MODEL RESULTS (FIRST ITERATION)
FOR ONGOING PD PREDICTING STUDENT OUTCOMES

	Est.	**Std. Error**	**t**	**Sig.**
(Constant)	3.400	0.446	7.633	.000
Teacher-Centered Pre-Writing Score	0.002	0.015	0.100	.921
Student-Centered Pre-Writing Score	0.002	0.002	0.760	.448
Teacher PD Writing Activity	-0.003	0.010	-0.307	.761
Teacher PD Video Watching	-0.426	0.381	-1.117	.273
Teacher PD Mini-Simulation	0.008	0.008	0.934	.358
Teacher PD Email Bulletin Use	0.156	0.010	1.493	.146
Teacher PD Teacher Log On-Time	-0.017	0.028	-0.607	.548
Model Fit Statistics	RMEL Convergence Criterion		Residual Variance	Residual Std. Dev.
	2247.6		1.268	1.126

In a previous study with this same student-level data set, the efficacy of the GlobalEd curricular intervention was investigated without consideration of the oTPD program. Without any of the teacher PD variables, the model showed significant effects for the student-centered pre-writing score predicting the dependent variable score, indicating that the GlobalEd curricular intervention worked as intended and had an effect on students' writing skills (Lawless et al., 2018).

In consideration of the effects of the oTPD program on student writing skills growth, the results for the first HLM model in Table XIV reveal that each of the GE2PD variables failed to significantly predict the student-level writing outcome at $p < .05$. To optimize the model, variables were removed one at a time and the model was iteratively re-analyzed. Each iteration removed the non-significant variable that had the lowest absolute t-value, and thus the least explanatory power. For instance, for the first iteration after the initial model (i.e., iteration 2), the teacher writing score was removed from the model, as it had the lowest absolute t-score of -0.307. With each iteration of the model (5 total iterations) and multiple non-significant variable removals, none of the independent GE2PD predictors achieved statistical significance at $p < .05$. Additional tables of the four additional iterations are not necessary, as each resulted in non-significant results. Thus, Hypotheses 5 and 6 are not supported.

Similar to the analysis in the first HLM model, the second HLM model seeks to identify whether teachers' curriculum adherence predicted students' achievement in scientific argumentation writing skills. Table XV provides the results for this second model, including the model-fit statistics using the RMEL criterion for converging HLM models.

TABLE XV

HIERARCHICAL MODEL RESULTS FOR TEACHER CURRICULUM ADHERENCE PREDICTING STUDENT OUTCOMES

	Est.	Std. Error	t	Sig.
(Constant)	3.121	2.160	14.449	.000
Teacher-Centered Pre-Writing Score	5.682	1.287	4.416	.000
Student-Centered Pre-Writing Score	1.491	3.848	3.875	.000
Teacher Curriculum Adherence	7.724	1.507	0.513	.612
Model Fit Statistics	RMEL Convergence Criterion		Residual Variance	Residual Std. Dev.
	2184.3		1.244	1.115

In the second HLM model summarized in Table XV, there is no observed relationship between the teacher adherence and student learning outcomes. The adherence variable was not observed to be significant at $p < .05$, although the variable was positively related to the outcome variable at its nominal value. In addition, this model reveals that the curricular intervention itself was effective at promoting student writing achievement, with both the student-centered and teacher-centered writing scores significant at $p < .05$. Students exhibited higher outcome scores at post when accounting for their pre-scores, although the teachers' degree of curricular adherence was not observed to predict a greater degree of student achievement. As a result, Hypothesis 7 is not supported given the observations in this study.

CHAPTER 5: CONCLUSIONS

This dissertation developed and explored a moderately comprehensive approach to oTPD program evaluation. Using a comprehensive review of the literature in professional development design and findings of efficacy, the study within this dissertation primarily focused on the measurement of exposure to and the effects of individual PD program design features. The analyses within the study examined the effectiveness of individual design features toward achieving the dual goals of influencing teacher practices and student outcomes. In addition, oTPD programs, as well as all professional learning interventions in general, should evaluate program effectiveness based on the specific goals of the program in relation to the features that are employed to bring about those goals (Fishman et al., 2013). Indeed, no single efficacy evaluation can capture everything or account for all possible confounding variables and influences. However, studies on oTPD efficacy should continue to strive for robust analyses and substantial specification in the design and effects of the individual features in the program. Such rigor can prevent PD literature from reporting programs that exist in a research paper as a "black box" with little to no specification and analysis of their designs, with researchers subsequently unable to discern any valuable insights from the literature.

In addition to evaluating the efficacy of an oTPD program, this dissertation also provided specific design descriptions of each of the elements within the program. The literature review confirmed that a number of design principles for oTPD interventions are now widely accepted in a consensus among scholars and designers. However, the literature review in this dissertation also confirmed that there remains a lack of an implementation consensus on what combinations of content, software, media, and other technologies should *specifically* be used in oTPD intervention design to meet desired outcomes. In addition, such reporting allows designers and researchers to share and benefit from a robust literature on the specific designs that implement the PD design principles that are widely accepted in the field. By providing specifics on design, studies address the shortage of information toward the development of the implementation consensus in the field, which can give designers and researchers references to exact details on how and why features were implemented toward certain goals (Rice & Dawley, 2009).

This study ultimately sought to contribute to the body of research that addresses the need to simultaneously link each of an oTPD's design features with outcomes, which has been repeatedly prescribed by literature reviews of the field's work as well as the scholars of the field (Borko, 2004; Desimone, 2009; Fishman et al., 2003; Lawless & Pellegrino, 2007; Penuel et al., 2007; Wayne et al., 2008). The empirical study in this dissertation evaluated an oTPD program at the *feature level* to identify level of teacher participation with specific design elements within the PD and what effect the participation with these individual features had on both teacher and distal student outcomes. The elements of writing activities related to teacher practice and weekly journaling via teacher logs that were found to be effective predictors of teacher practice provide further evidence on techniques, technologies, and activities for teachers to engage in professional development that has an impact. Although some elements of the PD did not have any observable effects on teacher implementation practice or student outcomes, these elements might still be required elements of communication and help facilitate teachers' participation with the more active elements of the PD. This can preliminarily be evidenced by the moderate correlations between features. Thus, the elements that did not have any effect observed do not necessarily lack value because an effect was not observed, but instead point to future iterative improvements and practical refinements to increase the effectiveness of a feature.

This study predominantly revealed evidence that the more intensive and participatory activities had an impact on teacher practice, as measured by teacher curriculum implementation adherence. Specifically, this study provides further confirmation of the general design principles of *active learning, social learning,* and *connection to teacher practice.* The features that predicted curriculum implementation adherence predominantly required active participation on part of the teachers and were inextricably tied to their practice. Teachers also shared their work and thoughts with GE2 staff and other teachers, with the opportunity to receive feedback and support.

Because the predictive effect of the more active teacher written activities is statistically significant and has a high beta value in comparison to the other two up-front PD variables, this feature was observed to be the most substantial element in promoting teachers' future implementation practices observed during the GE2PD. One explanation for this effect is the intensive time and effort requirements that each of the written tasks demanded of teachers for their completion, especially in comparison to other activities. Written activities, especially ones intended for use in one's own practice (as the GE2PD intended), typically require more focus, planning, and effort than watching video or even reading. Indeed, most of the time spent in the up-front PD course may have been on video, but video is notoriously passive in comparison to many other activities. Indeed, it may not be that it was the *act of writing* or even the content that teachers were writing about that prompted the observed effects, but perhaps more simply that the written activities likely drew the most intensive effort from the teachers during the up-front training course. This effort-intensiveness characteristic of the written activities could explain why video was observed to have virtually no predictive capacity toward teachers' future practice, but the two more intensive and active activities of writing and mini-simulation participation did.

The confirmatory evidence of these features' effects on practice is an essential finding of this study and demonstrated what worked best about the GE2PD, both in up-front and ongoing PD modes. That active learning and activities that are tied to practice showed predictive effects should be expected, but many PD programs continue to lack in active tasks and rely on passive media. Although the media consumption elements within the GE2PD are useful and necessary to convey information (e.g., email bulletins and video), they do not have the same degree of impact that active tasks have (Antoniou & Kyrikides, 2013; Desimone, 2009; Timperley & Alton-Lee, 2008; Wilson & Berne, 1999).

In the case of examining PD programs at the feature level, having no observed effect does not necessarily mean that a feature doesn't work, but instead was not observed to have an effect in this specific study. However, such non-significant findings do certainly provide developers and researchers a good opportunity for reflecting on ways to improve the intervention. Indeed, it could be possible that the instruments or measures within the study were not sensitive enough to capture phenomena occurring within a feature. As each feature was observed to be used with varying degrees by each teacher, it likely that each of the design features served some purpose within the GE2PD. To better understand the non-significant effects from design features, it is productive from a design and research perspective to treat individual features without observed effects as opportunities for improvement to examine how it structurally benefits the intervention, investigate how the features are used by participants, and hypothesize how the features might be more effective at helping teachers meet desired goals. This is a reflective moment for both designers and researchers to iterate their programs and implement new activities that are based on known learning principles and effective designs to promote the demonstration of effects in evaluations of oTPD programs (Lawless & Pellegrino, 2007; Wayne et al., 2008).

In the case of the GE2PD, the video and weekly email elements as features of the PD with non-significant effects deserve revisiting and refinement to identify why no observation of effect occurred in comparison to those elements that did work in the GE2PD. As mentioned above, the passivity of the media in each of these elements do not lend well to more active effort on part of the teachers. Although these features may provide an essential structural role and may directly support the teachers' other PD activities through the communication of information, these features could perhaps benefit from iterative design to improve their direct impact on teacher and student outcomes. A productive area of future research would be the investigation of the interactions between individual features to identify how features support other features, when features are structurally required for the use of other features, or discover emergent behavioral patterns among participants that arise during the intervention in how features are used in combination. It is plausible that features that do not significantly predict outcomes may instead be supportive of other features that demonstrate high levels of efficacy. This type of coordination and structural dependency among features is also valuable design information for researchers and instructional developers.

Although non-findings are opportunities for improvement, there is also additionally something to be said for the sensitivity of measures and instruments within efficacy studies. This dissertation forwarded new methods for measuring interactivity and participation within digital professional learning environments, but much work still needs to be done in the emerging field of learning analytics and educational data mining. There is also a perennial need for more sensitive instruments, especially with the intent of investigating the effects of teacher PD interventions on distal student outcomes. This study was an attempt at one step toward this goal of robust analyses of what works and why for both teachers and students by identifying at each point in the chain of logic where features worked and didn't work. Although the PD features in this study did not exhibit a significant effect on distal student outcomes, a lack of findings can also indicate challenges with achieving statistical power or the use of measures that do not capture phenomena with high enough resolution to produce a meaningful result. Because the distance between the PD features and distal student outcomes is quite spread out, the knowledge that there was no observed distal impact can encourage researchers to design new measures and instruments that capture phenomena with new degrees of sensitivity.

Similarly, although there was not a link observed within the two HLM analyses regarding the predictive effects of the GE2PD and teacher adherence to implementation on student outcomes, these hypothesized links should also not be immediately dismissed as non-existent, either. For this specific study and the limitations it encountered, there are multiple explanations that could be probable for the lack of observable significant results that link teacher PD participation or teacher adherence with student outcomes in this study.

First, the adherence measure for this specific data collection year was not able to be computed at a high level of resolution due to the nature of the existing secondary data source regarding teacher practice. Because the simulation digital log file data did not separate student issue area group posts, but instead only recorded when *any* student from a classroom posted in the simulation, the system failed to capture individual student or group-level participant behaviors. Only classroom-level behaviors were captured, which presented a challenge in identifying high-resolution interactions between individual students and issue area groups. This group-level dynamic was an important expected curricular activity among teachers, but the data capture methods failed to record these interactions and thereby reduced the variable's explanatory power regarding the degree to which a teacher performed expected curricular tasks.

Because of the lower-resolution adherence data than would be desired for such as study, it was therefore likely more difficult to link PD participation to distal, indirect outcomes from parties who did not participate in the PD. In short, the instrument perhaps lacked the sensitivity necessary to capture this link.

Second, in a similar vein, the original student-level dataset with which this study explored links between PD and student outcomes suffered from a substantial loss of cases as the data were transformed to suit the purpose of this study after the data processing steps began. Primarily, all teachers who were *not* newcomers to the GlobalEd curriculum were initially removed, as they did not participate in the up-front GE2PD components. This necessarily removed a substantial number of teachers and their students from the dataset (> 20) and reduced the explanatory power that was in the dataset as it was designed for its original purpose. Additionally, any student that did not participate in the GlobalEd curriculum were also removed, as it was not expected that teacher's adherence of the GlobalEd curriculum would influence students not receiving GlobalEd. This further reduced the number of students in the study from 1,996 to 704. Finally, because of inevitable missing cases between pre- and post-assessments of students' scientific writing skills, the number of cases were further reduced. The HLM models removed student cases linewise when it encountered a missing case within the pre column, post column, or both columns. As a result, the number of students was further reduced from 704 to 659 because of unavoidable data loss from collecting field data in authentic classrooms. Students miss school, do not choose to participate in a component of the research, or do not complete assessments for any number of valid reasons. As a result of this reduction in the data that occurred during the data-processing step of this study, the number of students in this secondary data analysis was likely less than was required to achieve enough statistical power to observe small effect sizes.

Third, because this group consisted of only first-year teachers with the GlobalEd curriculum, it could be possible that teachers' novice-level implementation patterns did not have a substantial effect on student outcomes. Instead, in addition to the above-mentioned grain-size, variable design, and statistical power considerations, it is also possible that a common "first year" pattern of adherence emerged, with most teachers following the base expected curricular events and opting to avoid flexibility an adaptation in their first year of implementation. Because participants in this study were all novices with the GlobalEd simulation, they may not have fully grasped the implementation of GlobalEd, nor learned how to flexibly adapt the simulation and its curricular resources to meet their needs while maintaining the underlying goals of the experience. As a result, novice teachers might have followed a general trajectory in implementation that does not actually demonstrate much variance.

The descriptive statistics in Analysis 1 provide initial evidence to this point, as there was a limited maximum that could be earned for the variable (15), and although the minimum was a 2 (i.e., very low adherence), such low adherence was rare (only 1 or 2 teachers). Instead, the mean score was 9 with a standard deviation of 2.72. Within one standard deviation, most teachers followed the expected curricular events within a few points of each other (e.g., 6 to 12, and only in whole-number increments), thus limiting the amount of variation in the variable. In a study like this, if there is little variance in any participation variable, there will likely be no statistically observed relationship between the independent and dependent variables. Such a "first year" patterns analysis is an excellent opportunity for further investigation into the degree to which novice teachers in a curriculum have varying implementation patterns and how these may subsequently be linked with student outcomes.

The challenge of achieving statistical power for larger-scale studies and linking PD outcomes to student outcomes therefore continues to be a perennial limitation of conducting secondary research when conforming prior datasets to match the needs of present research questions. It also represents a limitation of the field as a whole, as the field lacks an overall robust investment in PD interventions and initiatives for basic research in the impact of professional development programs concerning their ultimate influence on student outcomes.

Although this study did find links between the PD program and teacher classroom practice, it possibly became stretched too far to extend those individual design feature links to student outcomes. This exploratory analysis sought to use secondary data to observe links between PD participation and student outcomes. However, it could not observe significant relationships between elements in the far-reaching chain of logic between teacher PD participation, teacher classroom practice, and students' learning outcomes. A substantial amount of distance exists between teacher PD participation and their classroom practice. However, an even greater distance exists between teachers' classroom practice and students' ultimate degree of learning outcome achievement. This distance certainly influences researchers' ability to specify factors that play a certain role in achievement.

Many factors exist in the implementation of curriculum interventions and how and why students may or may not achieve desired results as a function of the curriculum implementation. A complex web of variables including home, social, and community life, socioeconomic status, access to information and resources, the environmental considerations of schools, and policies at individual schools all influence student learning. Although the analysis of the GlobalEd curricular intervention on its own demonstrated significant learning results, the addition of the individual PD variables or the adherence variable could not specify links with student outcomes. This can be a result of the lack of resolution or not small enough grain size in the variables considered within this study, but can also represent the well-documented extreme difficulty in linking a subset of teacher activities within PD and classroom practice to students' individual level of achievement as a result of classroom interaction (Hochberg & Desimone, 2010; Penuel et al., 2007; Wayne et al., 2008).

As highlighted in the literature review within the first section of this dissertation, the challenge of linking student outcomes with PD interventions is exacerbated by most teacher PD research being conducted only as a secondary focus to the more widely funded initiatives of curriculum interventions, classroom reforms, and educational policies. As such, PD research occurs rarely on its own merits, but instead within the contexts of larger curricular initiatives or basic research on curricular reforms. To study specific links in the chain of logic upon which interventions are designed, more sensitive instruments and measures are necessary, as well as a renewed dedication to funding and conducting original, high-powered PD research that can observe these links is needed to overcome the limitations of secondary research (Hochberg & Desimone, 2010; Wayne et al., 2008).

Specifically, the secondary analysis conducted within this dissertation illustrates the need for more basic research on PD and oTPD programs, especially to make logical connections between PD interventions and distal outcomes. In other words, it is a rather long stretch to connect a PD intervention that has no direct interface with students to the ultimate desired student outcome. This could be a function of statistical power or appropriate instrumentation that can capture high-resolution information about phenomena, which can be solved most easily through basic research that conceptualizes these concerns at the outset of a study program. Secondary analyses are still useful as well, as was observed in this study. However, after many cases had to be removed during data processing from an otherwise well-powered dataset to make the secondary data comply with the research questions being asked, it is evident that future basic research and investment in studies on the effects of professional development would be highly valuable to the field.

Although this study examines specific teacher practice and student outcomes and may not be completely generalizable to all PD goals, it does indeed provide direct and robust evidence to the field on methods that work and do not work for this context. The rigor employed in this study also takes a step toward meeting the ongoing calls by the field to better include essential elements within efficacy studies in oTPD, such as program participation, exposure to design features within an intervention, and links between both teacher and student outcomes to oTPD programs. To these ends, all oTPD programs should continue to strive to provide greater specification and detail in research reports in areas related to program design and implementation, the intent of each design feature, honest reporting of individual feature and program effectiveness based on established goals, and the varying amounts and types of participation by which teachers participated with oTPD features. These sources of information are vital to the continued success of the field and building that elusive repository of design principles and knowledge of “what works and why” in oTPD interventions (Lawless & Pellegrino, 2007).

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APPENDIX A

Teacher Written Projects Scoring Rubrics

Coded for presence / absence of each item as described

Project	Items	Scoring method	Total points for project
Project 1: Introductory Letter to Parents about GlobalEd	Teachers should craft a letter to parents describing GE2 1. Formatted as a letter to parents; conventional letter 2. Describes differences between GE2 and other curricula/activities 3. Describes benefits of GE2 4. Fewer than 200 words (as described in expectations)	1 point for each item that is present	**4**
Project 2: Problem-Based Learning Lesson Plan	Two separate activities should be presented For each of the two activities: 1. Describes the activity 2. Context described for the activity and when/how students will do it 3. Guiding questions provided for the activity 4. Describes different roles that students can take 5. Describes how students work will be reviewed / evaluated 6. Describes how feedback will be provided to stduents	**6** points for each item that is present in *each* activity **2** separate activities	**12**

Project 3: Assessment Plan	5 formative assessments and 2 summative assessments should be provided. For each assessment: 1. Describes what will be assessed conceptually and within which context / activity 2. Describes how the activity / concept will assessed, how evidence will be evaluated	**2** points possible within each assessment for each present item **7** total assessments (5 formative + 2 summative)	**14**
Project 4: Social Studies Country Position Statements	Provide 2 different positions for 3 different hypothetical countries for the given scenario Countries: Upandcomer, Middleground, & Lowlyone Positions: Competitive & Collaborative For each position, scored based on presence of expected elements within a position (greeting, claim, evidence for claim, and reasoning linking claim+evidence): 0 = position not present 1 = a position is presented, but does not include all the expected elements 2 = comprehensive position, all elements of the position provided	**2** positions for each country, each of which can score 0-2 based on presence of expected items. **3** different countries	**12**
Project 5: Science Essay using Claim-Evidence-Reasoning	Scored based on presence of specific expected elements in the essay, which was provided to teachers beforehand: - Choose and describe a real city - Describes causes of population growth - Describes annual rainfall level - Describes how rainfall might have changed related to climate change - Describes where the city gets water - Describes city water infrastructure - Describes future water challenges - Describes city water scarcity mitigation - Describes city future quality of life - Written in conventional essay format	**12** separate items	**12**

	- Provides claim-evidence-reasoning argumentation structure - Cites and links to external evidence used in the essay		
Project 6: Opening Statement for Oil Spill Mini-Simulation	Teachers write an opening statement and post in the mini-simulation. Coded for presence of expected elements within an opening statement: 1. Includes a salutation 2. Describes why the problem scenario matters to the country 3. Describes what the teacher's assigned country has already done to address the problem scenario 4. Describes the best course of action (in the opinion of the writer) 5. Offers reasons why other countries should care about the problem scenario 6. Includes a closing / conclusion 7. Written in the role of the country throughout 8. Uses Claim-Evidence-Reasoning structure (scored 0-3) 9. Provided comments on other participants' opening statements in the mini-simulation	Items 1-7: **1** point for the presence of each item Item 8: 0 = no CER structure 1 = Claims provided only throughout the essay, no specific evidence 2 = For each claim, specific evidence is provided 3 = For each claim, evidence and reasoning are provided that link back to the claim Item 9: Up to 2 points for commenting on up to 2 other teachers' opening statements (1 point per comment)	**12**
Project 7: Technology Plan	Coded for presence of expected items in the technology plan: 1. Describes what kinds of technology the class has available 2. Describes the different roles the teacher expects or plans to have students play with technology, or how students might use tech differently in groups	**1** point for each expected item	**3**

3. Describes strategies teacher may use to prevent technology "hogging," control, or bullying by students		
	TOTAL POINTS:	**69**

APPENDIX B

Student Assessment: Scientific Argumentation Essay

Persuasive Essay

2018-19

Student's Name: ___________________________________

Teacher's Name: ___________________________________

School: __________________________

Today's Date: ________ ________ ________
Month Day Year

Your responses are confidential and will not be associated with your name or identity. Only the researchers will know your answers to the questions and they will not be shared with your teachers, parents or other students.

You do not have to answer any question that you do not want to. Only group responses will be reported.

Persuasive Essay on Social Studies and Science

Prompt: The world is in danger of running out of fresh water. Do you think this is true? Do you agree or disagree with this statement? Why?

Assignment: Write a **persuasive** essay stating your point of view on the prompt above. Give evidence to support your answer and provide your reasoning why this evidence supports your claim. Use your knowledge about water, science, world geography and cultures to help you write your response. You will have a total of 30 minutes to complete your essay.

Directions
Take a few minutes to plan your paper. Make notes on the other side of this page. An outline may help you plan well.

1. Decide if you **agree** or **disagree** that the world is in danger of running out of fresh water. Take **one** position on this issue.

2. Think of evidence that supports your position.

3. Think of reasons why this evidence supports your position.

4. Organize your ideas carefully.

5. Manage your time to allow for **writing** a closing statement.

After you have planned the paper, begin to write. Finally, proofread your finished paper to check for correct sentences, punctuation, and spelling.

APPENDIX C

Scientific Argumentation Essay Scoring Rubric

Note:
This dissertation makes use of a pre-existing dataset measuring pre-post student argumentation skills before and after a curricular intervention. This rubric was used to score the assessment in Appendix B. However, this rubric was not used in this dissertation to score student data as the data were previously generated. This scoring rubric is provided only for historical reference as to how the dataset was originally generated.

GlobalEd 2 Writing Rubric: Claim-Evidence-Reasoning
This Rubric is designed for the pre- and post- GE2 essay prompts.

Raters: This is about CHAINS of logic that need to tie together. Quickly review the essay before scoring. If there is more than one chain, identify the BEST single logic chain in the essay and score only that one. If there are multiple chains that are all the same quality, pick the first of these as the chain to code.

Of high importance – DO NOT BE SWAYED by the "look" or length of an essay. Read it carefully! Neatness and quantity are NOT proxies for a well-formed essay! There are MANY examples of neat essays free of spelling and grammatical errors that contain a lot of content (evidence), but that are not advancing CER chains in a systematic way… **You have to really concentrate on what CERs the student is trying to advance and divorce that from aesthetics!**

What is a C-E-R logic chain? There are 3 parts to a CER logic chain:

(1) The Claim;
(2) The Evidence; and
(3) The Reasoning.

The Claim is an assertion or conclusion that addresses the original inquiry question.[1] The Evidence is scientific information or content that supports the student's Claim. Evidence can come from an experiment that students conduct or from another information source such as a journal or news article, a textbook, or a data archive. The Evidence needs to be relevant to, and sufficiently support, the proposed Claim. The Reasoning provides a justification that **links** the Claim and Evidence and illustrates why the data counts as Evidence to support the Claim by using the appropriate scientific principles.

For a complete CER, all the components must be linked together logically. The components do NOT have to appear in order of Claim, then Evidence, then Reasoning.

For instance, a student may present Reasoning, then Evidence, then sum up with a Claim. ("If humans do not find some way to remove pollution from water, then we may run out of water. (R) Already, water shortages due to pollution have been seen in Africa and Asia. (E) I believe we may run out of water because of extensive water pollution. (C).") It is fine to code this as a CER chain.

However, you may NOT "cherry pick" CER components that are not related throughout the essay. For instance, a student may have one CER chain with a good Claim, another chain with excellent Evidence, and another with very solid Reasoning. For each component of the prompt, you must pick the **one chain** that is overall the best and code the 3 components from that one chain.

[1] For this essay task, the Claim must be more specific than a simple "yes" or "no." See Claim section below for more information.

Examples of CER chain:

Chain	Claim	Evidence	Reasoning
Water	*"The world is in danger of running out of water because the population is growing rapidly."*	*"Scientists estimate the world population could climb from 7 billion now to 10 billion within the next 100 years."*	*"If the population continues to grow, we will need to find new water resources to feed a larger population or else some people will go hungry."*

Student Essay Assignment

Prompt: The world is in danger of running out of fresh water. Do you think this is true? Do you agree or disagree with this statement? Why?

Assignment: Write a persuasive essay stating your point of view on the prompt above. Give evidence to support your answer and provide your reasoning why this evidence supports your claim. Use your knowledge about water, science, world geography and cultures to help you write your response. You will have a total of 30 minutes to complete your essay.

Note that it is not likely for an essay to score perfectly in every essay scoring section, especially given the 30-minute timeline given for composition.

RUBRIC Key

Essay Position (0-1-2-3)
What is the student's position in the essay?

0 = No position
Student has written about something unrelated to the topic of water shortages
Student has no position, for or against…. Agree or disagree.

1 = Agrees with prompt
EX1 "We are in danger of running out of water for everyone."

2 = Disagrees with prompt
EX1 "We have enough water for everyone."
EX2 "We are not at risk for running out of water."

3 = Student presents both positions (for and against) or some other complex position
EX1 "The world may or may not be running out of clean water."

Claim (0-1-2)

The Claim is NOT a restatement of the prompt. The Claim is the *causal connector*–the *because* of the essay. It is the statement addressing WHY they believe the world is or is not running out of food and water. It does NOT have to contain a direct causal connector. You as the rater can infer the missing the word "because." Note that it may be difficult or impossible to evaluate a Claim outside the context of the associated Evidence and Reasoning.

0 = Absent Claim

Cannot discern a Claim or Claim DOES NOT RESPOND TO PROMPT.

EX1 "Yes…because…you can die after 3 days without water." (This Claim is technically unrelated to the prompt, which focuses on water shortage.)

1= Partially-developed Claim

The Claim is not completely clear but the student's meaning can be inferred. The Claim may not make sense until you read some of the Evidence and/or Reasoning. Also, there may be only a vague connection between the prompt and the Claim.

EX1 [Yes…because…] "The earth is getting destroyed from chemicals from waste in factories." (This Claim is followed by Evidence that pollution is affecting water sources. Again, we only understand the Claim after reading some Evidence; therefore, the Claim is not well developed.)

EX2 [Yes…because…] "The world is going to have 10 billion people in a few years." (This jumps right into Evidence. The inferred Claim, which is not written on the page, is that the population will require more water and/or use up all existing water.)

2 = Well-developed Claim

The Claim is clearly identifiable and explicit. You do not need to make any inferences to identify the Claim. The Claim makes sense even outside of the essay context. You can see where the argument is headed and how it will connect to the prompt.

EX1 [No…because….] "There is a large amount of water throughout the world and we can continue recycling it."

EX2 [Yes…because…] "The world is in danger of running out of water because there are more people than ever before who will need more water to drink."

<u>Evidence (for the presented Claim) (0-1-2-3)</u>
If there is no Claim, then there can be no Evidence or Reasoning. Essays that receive a score of 0 for Claim must also receive a score of 0 for Evidence and a score of 0 for Reasoning. When evaluating Evidence, be sure to also consider the Claim and Reasoning. For a score of 2 or 3, Evidence should have good content **AND** also connect logically to the Claim. Evidence does not have to be perfect but should be reasonably correct; i.e., Evidence about aliens or Santa Claus or fantastical scenarios should be scored 0.

0 = Absent Evidence
No Evidence provided for the presented Claim, including Evidence that is totally unrelated to the Claim OR Evidence has no basis in reality (e.g., Santa Claus, aliens).

EX1 (Claim: "the world has plenty of water.") "If we didn't have enough water, people would die. You can live only 3 days without water." (Evidence about the danger of water shortage is unrelated to the amount of water in the world, which was the Claim.)

1 = Partially-developed Evidence
Provides some Evidence, but it is either weak or incomplete or the Evidence is related to the Claim <u>but</u> it requires an inference, rather than being clearly stated. This could include Evidence that is strong in terms of content but is not *clearly* connected to the Claim. The Evidence does <u>not</u> have to be specific data.

EX1 "The world is full of lakes and rivers." (This is a reasonable statement but not enough to support a Claim that the world water supply is basically unlimited.)

2 = Well-developed Evidence
The Evidence is related to the Claim and does not require an inference; clearly stated. The Evidence does <u>not</u> have to be specific data.

EX1 "Technologies like drought- and pest-resistant crops, drip irrigation, and soil analysis maximize the limited amount of water we have for irrigation. This helps us conserve our water."

3 = Well-developed Evidence *<u>including data</u>*
This score is reserved for the highest level of Evidence. Clearly stated ***and** includes stated reasonable data.* Data need not be exact (e.g. for world population, 6-8 billion would be acceptable) but should not be made up or totally off base (e.g. the world's population is 3,000 people). The data must be used in the context of well-developed Evidence that is related to the Claim as required for a score of 2. The mere presence of data does not necessarily warrant a score of 3.

Reasoning (that connects Evidence and Claim) (0-1-2)
If Claim or Evidence is missing, then there can be no Reasoning. Reasoning **MUST** provide the **LINK** between the Evidence and the Claim. Reasoning tells how the Claim and Evidence are linked together. This section must address the WHY portion of the prompt. Reasoning needs to be written on the page, not inferred by the scorer.

0 = Absent Reasoning
Provides no Reasoning LINKING Claim and Evidence. Includes extremely superficial reasoning such as "this is why my evidence supports my claim" (with no further reasoning provided).

1 = Partially-developed Reasoning
Reasoning LINK is incomplete or weak or clearly incorrect, but it does follow from the Claim and Evidence provided in the essay.

EX1 [Claim: There is a large amount of water in the world and it is a renewable resource; Evidence: water cycle moves water from one place to another.] "Just because [some countries] don't have enough water there doesn't mean we don't have enough for everyone." The Claim mentions abundance of water and water as a renewable resource; the Evidence mentions the water cycle and a global water system; the Reasoning implies distribution of water. Considered together, the Reasoning is present but is not a strong link between the Evidence and Claim.

2 = Well-developed Reasoning
Reasoning is well thought out and clearly **LINKS** Claim and Evidence. If the Claim or Evidence were weak (i.e. scored 1), it is unlikely that the Reasoning would be scored 2, because it would be difficult to make a strong link between a weak Claim and weak Evidence. Well-developed Reasoning may explain how an example supports a claim, follow an if-then format, be a "therefore" type statement, or take another form.

EX1 "More people on earth means more demand for water – if we all keep consuming the same amount of water, there will be a shortage."

Holistic Section

Scores in this section are for the overall essay. Score the following sections based on the holistic nature of the essay on Food/Water Relationship, Addressing the Opposition, Organization, Science Content and Social Studies Content. These elements may appear anywhere in the essay; they do not need to be directly attached to the CER chain coded above.

Addressing the Opposition (0-1-2)

Ideally, “opposition” consists of a clear counter-claim (more specific than agree or disagree) AND evidence and reasoning to rebut that counter-claim. Note that the essay prompt did not ask students to discuss opposition or provide a rebuttal, so it will be absent from most essays.

An essay with a “both positions” response (agree and disagree) is likely to address opposition. Look carefully at how the essay is structured. Two points of view that are simply presented side-by-side may not qualify as Addressing the Opposition. For full credit, the two points of view should be discussed as contrasting, potentially by using transitions such as “however” or “on the other hand.”

0 = Absent

There is no attempt to address the opposition OR opposing positions.

1 = Partially-developed

The opposition is addressed as either an opposing position or a counter-claim, but no rebuttal or a very weak rebuttal is provided.

EX1 “Some people think that we can always clean the water of pollution, but what if we can’t?” This is a clear counter-claim about decontamination, but the rebuttal “what if we can’t?” is not strong or specific.

EX2 “Africa is poor and water there is very expensive, so it appears that people might run out of water, but this is happening very slowly.” This response has a strong counter-claim (poverty is a cause of water shortage) but “happening very slowly” is a very weak rebuttal. It could have been made stronger if evidence and reasoning to support “happening very slowly” had followed.

EX3 “Some people think that we will run out of water, but they are wrong. I disagree with the prompt because…” This response acknowledges an opposing point of view but does not provide a counter-claim (i.e. *why* might people think we would run out of water?).

2 = Well-developed
Addresses the opposition with a clear counter-claim <u>AND</u> provides a rebuttal. <u>Rationale</u> – the student recognizes there are alternative views out there and provides counter arguments refuting the opposition.

EX1 "Some people believe we will not run out of water because we can use desalination, but desalination pollutes the ocean with too much salt. It would solve the problem of water shortage but create other problems like dead zones and killing fish." A clear counter-claim (desalination) and rebuttal regarding why desalination is not an ideal solution.

<u>**Organization (0-1-2)**</u>
Score the level of structure within the essay holistically. You are judging the organization of the entire essay, overall.

0 = Disorganized, difficult for rater to follow, no flow in the writing, may be garbled or off-topic (Not common)

1 = Clear attempt at organization but not optimized, thoughts not clearly flowing, *may or may not have a conclusion.*

2 = Coherent structure, typically includes paragraph structure (e.g., a five-paragraph essay with introduction, body paragraphs, and conclusion); may be an exceptionally-organized single paragraph that flows well and <u>includes a reasonable concluding statement or a conclusion paragraph</u>

<u>Science Content (0-1-2-3)</u>
Score the science content of the essay. You are judging the science content of the entire essay, overall (climate, food production, pollution, earth science topics, etc.). To what degree did the student mention, use, or explain scientific concepts? Remember that students may go off on tangents while elaborating their scientific ideas, but this should not negatively impact the essay's science content score.

0 = Absent
Essay may focus primarily on social studies content and/or personal experience. **Mere mentions of healthy food, clean water, eating, drinking, washing, fruits/ vegetables/ meat, rivers, lakes, oceans, farms, animals, hunger, etc. are not sufficient as these are too colloquial.** HOWEVER, if these same terms are used to describe science concepts or scientific processes, see Level 1. Although not an exhaustive list, the above terms are colloquially used in non-scientific ways, so we will NOT count them toward science content. Looking for scientific processes help scorers in this section determine between a 0 and a 1.

EX1 "People need water to drink and also to keep clean." (This touches on the biological and hygienic needs for water, but does not address the scientific processes that are studied in GE2).

1 = Uses Low-level Science Content
Colloquial terms may be used to describe scientific ideas, processes, or concepts such as nutrition, hunger/starvation, dehydration, hygiene, technology in general, disease in general. OR, includes accurate use of 1 scientific term (without explanation/definition of that term).

EX1 "People in many countries have water but it is muddy and filthy and makes them sick." (Addresses the consequences of water pollution in a scientific way, but did not get in depth)

2 = Partially-present Science Content
Includes either a brief, accurate discussion of 1 science topic OR effective use of 2+ scientific terms (e.g. specific technologies, specific diseases, climate, pollution, irrigation, dehydration, desalination, evaporation, condensation, precipitation, etc.). Scientific terms must be used in the context of an accurate statement or explanation.

EX1 (Single topic) "Desalination works by taking the salt out of ocean water. The machine heats ocean water to boiling and traps the steam—this steam has no salt in it. Then the machine cools the steam into water people can drink." This is a good explanation of the topic of desalination, using colloquial terms and explaining the general concept accurately and briefly.

EX2 (Multiple scientific terms) "Technologies such as desalination, drip irrigation, and filtration are all ways people can clean or conserve water to keep up with a growing population." This is an unelaborated, accurate, contextual use of 3 scientific terms. For a score of 3, the student would have to go on to explain what each of these technologies are, or explain one of them in great detail.

3 = Complete and Strong Science Content
Includes either: an exceptionally-elaborated, accurate discussion of 1 science topic **OR** discussion and explanation of at least 3 scientific terms. Reserved for outstanding responses that demonstrate high levels of scientific knowledge and application of science content.

EX1 (Single topic) Several paragraphs discussing how climate change impacts water, including how global warming, rising ocean levels, melting ice caps, and volatile weather make it difficult to maintain a steady supply of water.

EX2: (3+ scientific terms) An essay that accurately discusses/explains multiple technologies for water recycling using scientific terms, e.g. wastewater treatment, desalination, and nanotechnology filtration.

<u>Social Studies Content (0-1-2-3)</u>
Score the social studies content of the essay holistically. You are judging the social studies/social systems content of the entire essay, overall (geography, politics, economics, culture, human rights, etc.). Did the student mention social issues in their essay? Remember that students may go off on tangents while elaborating on social studies concepts, but this should not negatively impact the essay's social studies content score.

0 = Absent
Essay may focus primarily on science content and/or personal experience. **Mere mentions of people, money, countries, drinking, geography, etc. are not sufficient as these are too colloquial.** HOWEVER, if these same terms are used to describe social studies concepts, see Level 1.

1 = Uses Low-level Social Content
Colloquial social studies terms may be used to describe social studies processes or concepts such as: economy, differential access (some countries have water; some do not), geography, cultural values, human rights, choices people make, help from leaders around the world, regulation, laws/policies, trade/imports/exports, international relations/conflict, war/terrorism, connecting the environment to geography, such as tying deserts, rain forest, etc. to water resources in different parts of the world. OR, includes accurate use of 1 social studies term (without explanation/definition of that term).

Note: Simple mention of different states/countries is not sufficient, in terms of geography. Students have to connect geography to climate (see above), access, wealth, etc.

Note: This is not an exhaustive list of social studies content. Consider any topics/ideas that might reasonably be covered in a social studies class.

EX1: "Countries that have plenty of water should donate some to those that need it."

2 = Partially-present Social Content
Either a brief, accurate discussion of 1 social studies topic OR effective use 2+ social studies terms, e.g., economy, geography, politics, regulations, policies, imports/exports, international collaboration, human rights, culture. Terms must be used in the context of an accurate statement or explanation.

EX1 (Single topic) "In some countries, there are water sources but the government sells the water to a richer foreign country. If those countries would keep their water source for themselves, they would not have a water shortage, but they need the money for their economy." This is a good discussion of the topic of water and economics, using colloquial terms and explaining the general concept accurately and briefly.

3 = Complete and Strong Social Content
Reserved for either: an exceptionally-elaborated, accurate discussion of 1 social studies topic **OR** discussion and explanation of at least 3 social studies terms. Reserved for outstanding responses that demonstrate high levels of social studies knowledge and application of social studies content.

EX1 (Single topic) Several paragraphs discussing the politics of water sources including issues of ownership, wealth/poverty, economics, and local regulations.

EX2 (3+ social studies terms) An essay that discusses several implications of globalization, e.g. global trade, and a need for regulations to protect local resources from international interests.

APPENDIX D

Institutional Review Board Documentation

UIC UNIVERSITY OF ILLINOIS AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Institutional Review Board
FWA# 00000083

203 AOB (MC 672)
1737 West Polk Street
Chicago, IL 60612-7227
Phone: 312 996-1711 Fax: 312 413-2929
www.research.uic.edu/protocolreview/irb

FORM - Initial Review Application: Social and Behavioral Sciences

Version: 3.7
Date: 09/18/2008

To Be Completed By the Investigator	***For OPRS Use Only***
Date Application Completed: **06/10/2019**	UIC Protocol #: **2009-0412**
Application Document Version #:**6**	Assigned IRB:

I. Research Title: Expanding the Science and Literacy Curricular Space: The GlobalEd II Project

II. Personnel

A. Principal Investigator

Name (Last, First) **Lawless, Kimberly**		Degree(s) **Ph.D.**	University Status/Title **Professor**
Department **Educational Psychology**			College **COE**
Mailing Address **1242 EPASW**			E-mail Address **klawless@uic.edu**
Phone Number **312-996-2359**	Fax Number **312-996-5651**		M/C **147**

B. Faculty Sponsor – required when PI is a student, fellow or resident

Name (Last, First)		Degree(s)	University Status/Title
Department			College
Mailing Address			E-mail Address
Phone Number	Fax Number		M/C

C. LIST ALL ADDITIONAL KEY RESEARCH PERSONNEL ON APPENDIX P and SUBMIT WITH THIS APPLICATION PACKET.

III. Research Funding

Is this research funded?

☐ No. Go to Section IV.

☒ Yes or pending. Complete the rest of this Section (below).

Check all of the appropriate boxes for funding sources (including pending sources) for this research.

EXTRAMURAL:

- ☒ Federal Agency Name: **Institute of Education Sciences (http://ies.ed.gov)**
- ☐ Foundation Name:
- ☐ State Agency Name:
- ☐ Industry Sponsor Name:
  Is this industry-sponsored study investigator initiated?
  ☐ No ☐Yes – if YES, please see **http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0236.pdf** for fee schedules and instructions for submitting fees for IRB review of industry-sponsored research)
- ☐ Sub-contract from non-UIC agency or institution: Name:
- ☐ Other - Name:

INTRAMURAL:

☐ Campus Research Board (CRB) ☐ Departmental ☐ Other - Name:

Funding Identification: For each funding source, provide the following information and submit a full copy of the grant, contract, and/or sub-contract, including budget sections. Use **Appendix Z** if this study is supported by more than one funding source. **Note:** Any subsequent change in funder or funding status requires an IRB amendment.

1. Proposal Approval Form (PAF) Number: **00305875**

2. Name of the PI on the grant or contract received directly from the sponsor: **Kimberly A. Lawless, Scott W. Brown**

   Is the PI of this grant or contract affiliated with UIC? ☒ No ☒Yes

If **NO,**

Identify the agency or institution with which the above PI is affiliated: **Scott Brown is professor from the Univeristy of Connecticut (UCONN) and Kimberly A. Lawless is a professor at the University of Illinois at Chicago, UIC.**

Explain the relationship between that agency or institution and UIC: **This is a collaborative effort between the two universities.**

3. Funding Agency Grant Account Number: ☒Grant, contract or sub-contract pending.(For federally funded research, provide the federal grant/contract number assigned by the funding agency to allow OPRS to accurately complete the certification of federal funding document. OPRS will provide the certification to the investigator with the approval letter.)

4. Grant, contract or sub-contract title: **Refinement of GlobalEd 2 and Testing New Intervention Impact, Goal 2, Educational Technology**

5. Is this grant a Master, Training, or Development grant (grants used to train fellows or support the development of other research protocols)? ☐ No ☒Yes

PLEASE ATTACH A COPY OF THE GRANT, CONTRACT, and/or SUB-CONTRACT TO THIS APPLICATION.

IV. Conflict of Interest (COI)

A. Disclosure

All investigators must disclose all real, apparent, or potential financial conflicts of interest to the IRB. ***Investigator*** *is defined as any person responsible for the design, conduct, or reporting of the research. This includes, but is not limited to, the principal investigator, co-investigators, and other key research personnel.* ***Family members*** *include spouse and children.* ***Significant*** *means financial interests in business enterprises or entities that (when aggregated for the individual, spouse, and children) exceed $10,000 or represent more than 5% ownership regardless of dollar value. The $10,000 threshold also applies to salary, royalties, and other payments aggregated for the individual, spouse and children expected over the next 12 months. For more information, including examples and definitions, see the* ***Investigator Conflict of Interest Disclosure Policy for Human Subjects*** *at* *http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/index.shtml.*

1. Are any investigators, or family members thereof (spouse, children), major officers of, hold a managerial role in, or otherwise have a significant financial relationship with the research sponsor or any subcontract recipient (subcontractee)?

   Yes ☐ No ☒

2. Do any investigators, or family members thereof, have a significant consulting relationship with this sponsor or any subcontractee?
   Yes ☐ No ☒

3. Do any investigators, or family members thereof, have any other relationships, commitments (including assignments of Intellectual Property Rights), activities (including uncompensated activities) or financial/fiduciary interests that present potential or apparent conflicts of interest or commitment with this study, or are there any other potential conflicts of interest with the study?
   Yes ☐ No ☒

4. Does an institutional conflict of interest exist with this study?
   Yes ☐ No ☒

B. Management

If **YES** has been checked for any of the above questions, **attach a COI Statement of Explanation And Management (SEAM)** that describes the conflict and presents a plan for managing the conflict in order to minimize the effect on the design, conduct, or reporting of the research and/or the integrity of the human subject protection program. The COI-SEAM and guidance on how to write the COI-SEAM are available under the "Managing Conflicts" section of the COI website at www.research.uic.edu/conflict. Final IRB approval of the research cannot be provided until a management plan is in place.

UIC and JB VAMC personnel: For additional assistance contact the COI Office at (312) 996-4070 or email *coi@uic.edu*.

V. Performance Sites

Definition of a Performance Site: A performance site is a location at which the research is conducted, data is gathered from subjects and/or records, and/or subjects are consented into the research. Sites are performance sites whether the research activities there are funded or not funded.

Non-UIC Performance Site: A non-UIC performance site is a non-UIC location at which a UIC investigator conducts research activities. Sites may be non-UIC performance sites whether the research activities there are funded or not funded, or whether the research activities are funded through a UIC sub-contract or not.

Please note that the JBVAMC has special status as a performance site and that alternative documentation will be required in lieu of Appendix K for research activities conducted at the JBVAMC.

A. Performance Site Identification:

1. Will UIC be a performance site?
   ☐ No ☒ Yes
   Must be YES unless the research is conducted only at the Jesse Brown Veterans Administration Medical Center [JBVAMC]

2. Will JBVAMC be a performance site?
   ☒ No ☐ Yes

B. Non-UIC Performance Sites:

1. Are there non-UIC performance sites?
   ☐ No ☒ Yes (After completing this application, complete Appendix K and submit with this application packet)
2. Are there international performance sites?
   ☒ No ☐ Yes (After completing this application, complete Appendix I and submit with this application packet)

VI. IRB Disapproval of the Research

To your knowledge, has this protocol been reviewed and subsequently disapproved by any IRB?

☒ No ☐ Yes

If YES, please provide the details of the disapproval including the reviewing IRB name, the date of review, the issues resulting in disapproval, and how these issues have been resolved.

VII. Classified Research

Has this research been declared to be classified and/or does it involve any classified data or subjects?

☒ No ☐ Yes **If YES, STOP**. State of Illinois law and UIC policy does not permit classified research to be conducted at UIC.

VIII. Additional Reviews Required

Reviews beyond that of the IRB may be required for this study. Please indicate which of the reviews below apply to this study. If you have already received review approval documents, please attach.

Review	**Review Required ?**	**If YES, check that necessary documents are attached**
Departmental Review is only required by the IRB if the research must be reviewed by the	☐ **Yes**	☐ Appendix F is attached

convened Board. Each individual Department may, however, require Departmental Review as part of their internal policy.	☒ **No**	Approval date:
UIC Cancer Center Review is required prior to submission to the IRB for protocols to be reviewed by the convened Board; protocols eligible for expedited review may be submitted simultaneously to the Cancer Center and IRB www.uic.edu/com/cancer	☐ **Yes** ☒ **No**	☐ Cancer Center approval is attached Approval date:
Radiation Safety (RS)reviews laboratory operations regarding the use of radioactive materials, such as radioactive isotopes, and the use of devices that produce x-rays, such as research related DEXA scans. www.uic.edu/depts/envh/RSS	☐ **Yes** ☒ **No**	☐ RS approval is attached Approval date:

IX. Lay Summary

Summarize the proposed research using non-technical language that can be readily understood by IRB members whose primary concerns are nonscientific. The complete summary (parts A - F) must not exceed a total of 500 words. Use complete sentences.

A. Statement of purpose/and background information necessary to understand the study:

In the immediately preceding iteration of the study with our previous funding source (2013-2017), the goal was to rigorously test the efficacy of GlobalEd 2 and systematically investigate factors that moderate both proximal and distal outcomes. In prior research protocol (2013-2017), we: (a) tested the efficacy of GlobalEd 2 with urban and suburban students on the proximal outcomes of written argumentation quality, science topic knowledge, and self-efficacy and distal outcomes related to scientific literacies, science knowledge/process skills, and, interest in pursuing future science educational opportunities and careers; (b) replicated the efficacy trial with a second cohort of students (which also provided sufficient power for subgroup analyses); (c) examined the generalizability of the impact of GlobalEd 2 across different science topics; (d) evaluated the of impact of exposure to GlobalEd 2 across a full year of instruction (as opposed to only 14 weeks); and (e) considered how student, teacher, and school variables moderate (and/or mediate) response to the intervention.

The purpose of the present stage of the project (2017-2020) is to test revisions to and versions of the current GE2 curriculum in an evidence-based, iterative manner to better accommodate logistical issues faces by schools and teachers, creating a new version of the intervention, GlobalEd 3 (GE3). The current version of the protocol (v.15) outlines the research trajectory of the project for years 2017-2020. Research will be completed in three phases, with each phase focusing on the randomized comparison of various structural and technological elements of the GE2 curriculum.

B. Description of procedures/methods:
Multiple sources of data will be collected to compare the efficacy the GE2 simulation and curriculum. Students will complete four assessments before and after GE2 implementation. We will evaluate the effect of GE2 on proximal outcome measures, including written scientific argumentation, science and social studies topic knowledge, and self-efficacy. Distal outcomes, including scientific literacy, science knowledge/process skills and interest in pursuing future science educational opportunities and careers will also be assessed. Teachers' experiences will be evaluated using interviews, focus groups, surveys, and a weekly reflective teacher log.

C. Statement of duration of subject participation:
In addition to their consent for participation in an up-front summer PD workshop, we ask that teachers commit to implementing a full GlobalEd 2 simulation. Commitment to implement will be part of our screening process.

D. Anticipated risks:

We believe there are no known risks associated with this research study; however, a possible inconvenience may be the time it takes to complete the study.

E. Anticipated benefits:

Teacher participants may or may not benefit directly from this study. At the very least, teachers will learn more about science, writing, and problem-based learning and get access to a variety of teaching materials and recourses through our workshop.

F. Description of subject population including characteristics, age range and number of subjects at UIC, JBVAMC and study-wide.

The participants will be seventh or eighth-grade social studies teachers in intact classrooms. No special consideration will be given to gender, ethnicity, or age. Although, participants will be selected based on the following minimum requirements:

- **1 year at their current position teaching Social Studies**
- **Teaching at least one section of middle-school social studies**
- **Internet access (in classroom or lab)**
- **Availability for the professional development training**
- **Availability for the fall 2017 GlobalEd 2 simulation**

X. Categories of Research That May Be Reviewed Through Expedited Procedures

A. Eligibility for Expedited Review

Will this research involve prisoners as subjects?

☒ No ☐ Yes **If YES, STOP** and skip to Section XI. Research involving prisoners is not eligible for expedited review.

B. Eligibility as Minimal Risk Research

Will this research be minimal risk?

Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

☐ No ☒ Yes **If NO, STOP** and skip to Section XI. Research that is greater than minimal risk is not eligible for expedited review.

C. Expedited Categories

Please identify the expedited category or categories that apply to your research. If your research does **NOT** fit within any of the categories below, then please **STOP** and skip to Section XI.

1. ☐ Clinical studies of drugs and medical devices only when condition (a) or (b) is met. (a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (NOTE: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review). (b) Research on medical devices for which (i) an investigational device exemption application (21CFR 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

2. ☐ Collection of blood samples by finger stick, heel stick, or venipuncture as follows: (a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and children, considering age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

3. ☐ Prospective collection of biological specimens for research purposes by noninvasive means. Examples: (a) hair and nail clippings in a non-disfiguring manner; (b) deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction; (c) permanent teeth if routine patient care indicates a need for extraction; (d) excreta and external secretions (including sweat); (e) uncannulated saliva collected in an unstimulated fashion or stimulated by chewing gumbase or wax or by applying a dilute citric solution to the tongue; (f) placenta removed at delivery; (g) amniotic fluid obtained at the time of rupture of the membrane prior to or during labor; (h) supra- and subgingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylactic scaling of the teeth and the process is accomplished in accordance with acceptable prophylactic techniques; (i) mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings; (j) sputum collected after saline mist nebulization.

4. ☐ Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving X-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.) Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, Doppler blood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

5. ☒ Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected, solely for non-research purposes (such as for medical treatment or diagnosis). (NOTE: Some research in this category may be exempt from HHS regulations for the protection of human subjects 45CFR 46.101(b)(4). This listing refers only to research that is not exempt.) Please refer to the OPRS Getting Started Page at http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/getting_started.shtml for decision charts to assist in determining the level of review.

6. ☒ Collection of data from voice, video, digital, or image recordings made for research purposes.

7. ☒ Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication,

cultural beliefs or practices, and social behavior), or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects 45CFR 46.101 (b)(2) and (b)(3). This listing refers only to research that is not exempt.) Please refer to the OPRS Getting Started Page at http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/getting_started.shtml for decision charts to assist with the level of review.

XI. Protocol Components

A. Briefly state the research hypothesis being explored by the current research. Include a discussion of the present knowledge relevant to the research and the aims and significance of the research. Cite appropriate literature to support the relevance and importance of this research. (Please note: not necessary if completing Appendix G.)

There is no doubt that recent policy initiatives across local, state and national levels have placed increased pressure on schools to improve student performance in the domains of literacy, mathematics and science. Concurrent with the demands for accountability, academic standards in these areas have also expanded, requiring teachers to cover more material in a curricular space that had not grown commensurately. As a direct consequence, many school districts redesignated instructional time from other disciplines, such as social studies, in order to dedicate more time to subjects that are assessed through state-mandated, high stakes standardized tests (Knighton, 2003; Manzo, 2005; Marshak, 2003). However, it has been argued that because of the interdisciplinary nature of subjects like social studies, the shift in instructional time deprives students of the opportunity to ground their knowledge of literacy, math and science in areas that can demonstrate authentic applications, and promote learning outcomes. Problem-based learning researchers have illustrated for decades that leveraging interdisciplinary contexts as a venue to engage in real world problem solving can deepen students' understanding, flexibility in application and transfer of knowledge (Bednar, Cunningham, Duffy, & Perry, 1992; Koschmann, Kelson, Feltovich, & Barrows, 1996). Recognizing this, the GlobalEd 2 Project utilizes educational technologies currently available in most eighth-grade classrooms to build upon the interdisciplinary nature of social studies as an expanded curricular application aimed at increasing instructional time devoted to science and persuasive writing in a virtual environment.

The goal of this research is to inform the development of design priorities and design principles for future versions of this and similar curricula that can be delivered at large scale. In the coming years (2017-2020), the project team will test revisions to and versions of the current GE2 curriculum in an evidence-based, iterative manner to better accommodate logistical issues faces by schools and teachers, creating a new version of the intervention, GlobalEd 3 (GE3). Specifically, while the current 12- week version of GE2 produces positive and consistent results on tested proximal and distal outcomes, the synchronous elements of the simulation and the overall length of the simulation are difficult for many schools to manage. As such, the current research is planned in three connected studies: (a) systematically test the impact of the synchronous conferences (no conferences or 1 conference) with urban and suburban students on the proximal outcomes of written argumentation quality, science topic knowledge, and self-efficacy and distal outcomes related to socio-scientific literacies, science inquiry, and interest in pursuing future science educational opportunities and careers (to be conducted 2017-2018); (b) using the results of this first study, revise GE2 and test condensed versions of GE2 (8-week and 10-week) for impact on targeted outcomes (to be conducted 2018-2019); (c) using results of second study, revise GE2 accordingly and conduct a treatment/comparison pilot study of the new GE3 curriculum (to be conducted 2019-2020).

B. Please describe in chronological order all the tasks/tests or procedures subjects will be asked to complete in participating in this research.

Recruitment

Teachers will be recruited based on the following criteria:

- One year at current position teaching Social Studies
- Teaching at least one section of social studies to 7th or 8th graders
- Basic technology skills: email, Internet use
- Internet access (in classroom or lab)
- Availability for professional development (up-front and ongoing)
- Availability for participation in the implementation of the GlobalEd 2 simulation

All teachers that complete the GlobalEd 2 training workshop during the summer will be eligible to participate in the implementation of the three stages of the simulation in their social studies classrooms. All teachers will be offered an opportunity for informed consent to the research procedures at the beginning of the study, which will be documented.

Training

Teachers recruited to GE2 will complete a 15-hour up-front professional development (PD) program before fall implementation that will help orient them to GE2 procedures, problem-based learning, technology, and resources for GE2. During implementation in the fall, GE2 teachers will receive scheduled, ongoing, and on-demand PD training and support (i.e., podcasts, webcasts, forum) throughout the course of their participation in GE2. Ongoing PD will respond to teachers emerging needs while implementing the simulation, with topics including what GE2 is and how it works, problem-based learning and classroom strategies, flipped classrooms, written scientific argumentation, and the science content needed by teachers to effectively implement GE2 with students.

Teacher Data Collection

For the purposes of evaluating the efficacy of the GlobalEd 2 intervention, the following data will be collected at various timepoints during implementation:

1) Teachers will be asked to complete a short, 15-minute questionnaire in pre-/post-testing format, at three time points for each implementation period: (a) before the summer PD program (July), (b) after the summer PD program (August), and (c) after implementation (December).

2) For evaluation purposes, teachers' classroom and online activity will be observed and additionally may be videotaped during the three phases of the simulation, as part of classroom and implementation observations. We are requesting to have GE2 staff visit their classrooms up to once a week for observation purposes during the course of the simulation, which will be scheduled individually between teachers and GE2 project staff.

3) Teachers will be interviewed (30 minutes max) or participate in a focus group (30 minutes max) to provide us with more elaborate feedback on the simulation. Interview/focus-group questions are included with this application.

4) Teachers will complete a 10-minute teacher-log on a weekly basis.

Intervention Implementation

During each simulation, teachers will implement the three phases of the GlobalEd 2 project in their seventh or eighth-grade classrooms: (1) the preparation phase, (2) the simulation phase, and (3) the debriefing phase. The GlobalEd 2 simulation will focus on water or food security issues aligned to the national science standards. All curriculum and activity materials will be provided to teachers free of charge by the GlobalEd 2 staff. Additionally, the GlobalEd 2 staff will be available to assist with teachers' implementation of the intervention.

Student Data Collection

All students will have an opportunity to assent to participating in the study, as well as their parents having an opportunity to consent.

Students will be asked to complete 4, 30-minute assessments at the beginning of the semester and at the end of the semester for each simulation. All 4 assessments will total 2 hours of time to complete, but they can be spread out over the course of a week. The assessments are:

1. Persuasive Essay Task - an open-ended writing prompt, patterned after statewide, standardized tests of persuasive writing and related to the simulation topic (i.e. water scarcity).
2. Student Questionnaire (Pre/Post versions) – designed to gather students' demographic information (Pre-only), as well as test their science and social studies knowledge and attitudes.
3. Socio-Scientific Literacy – an instrument, which measures socio-scientific literacy in context. It focuses on interpreting pragmatic meaning from short passages focusing on socio-scientific issues.
4. Science Skills & Inquiry Task – a short-answer/multiple choice instrument designed to test students' science and inquiry skills.

In addition, if a student is a part of the GlobalEd2 simulation classroom, s/he will partake in writing activities as part of the GlobalEd 2 simulation. Consented students' writing products will be collected, coded and analyzed in order to evaluate the effectiveness of the GlobalEd 2 project.

C. If the research will require blood draws or the collection of other tissues performed solely because of participation in the research, please indicate the exact amounts and the frequency with which the samples will be taken.
N/A

D. Health Information Records

1. Does the research involve the use and disclosure of protected health information (PHI)?
☒ No ☐ Yes

Health information means any information (oral or recorded in any form) that is created or received by a health care provider, health care plan, health authority, employer, life insurer, school or university, or healthcare clearing house and relates to the past, present, or future physical or mental health or condition of an individual. For example, if you are reviewing, extracting data from, or creating medical records as part of this study, you are using PHI.

If YES, please choose one of the following options:

a. ☐ If yes, AND the ONLY data collected will be from health information records that exist at UIC and/or the UIC Medical Center at the time of IRB submission and no on-going or prospective collection of data will occur, STOP and complete a Claim of Exemption form.

b. ☐ If yes, AND data collected from health information records will be on-going or prospective, and/or outside of UIC and/or the UIC Medical Center, please complete and submit Appendix H with this application. Also include the use or disclosure of PHI in the tasks/procedures section of the informed consent document(s). If the PHI will be accessed at a UIC site, please submit a HIPAA Authorization document or request a waiver of HIPAA in Appendix H.

2. If subjects are to be selected from records outside the UIC Medical Center, indicate who gave approval for the use of the records. If the records are "private" medical or student records, provide the protocol, consent documents, letters, etc., for securing consent of the subjects for the use of the records. Written documentation for cooperation/permission from the institutional holder or custodian of the records should also be attached. **N/A**

3. Will the Principal Investigator and/or other Key Research Personnel accessing the health information records for the research already have access to the records for clinical care?
☐ No ☐ Yes ☒ N/A (the research does not involve access to health information records)

4. Will the Principal Investigator and/or other Key Research Personnel review the health information records to establish the subject's eligibility for the research?
☒ No ☐ Yes

If YES, then a HIPAA waiver for recruitment purposes must be requested on Appendix H and a parallel waiver of informed consent must be requested under 45 CFR 116(d) for recruitment purposes in Sections XIV and XV of this application form.

UIC hospital policy requires that all research subjects who have clinical visits and procedures be registered and that, at a minimum, a medical record containing the name of the research study, the responsible physician, the procedure(s) being performed, the medication involved, and adverse experiences be part of the permanent medical record so that, in the case of an emergency, the subject's involvement in a research study is known. UIC hospital policy also requires that a copy of the research consent document, Release of Medical Information Form, and HIPAA authorization form be part of the permanent medical record. This must be disclosed in the informed consent document.

5. Will any research related information be put into the health information records or any other permanent record of the subject? ☒ No ☐ Yes
If YES, please explain:

E. Eligibility Criteria

Please provide detail regarding the inclusion and exclusion criteria for enrollment of subjects into this study. Please include specific information regarding the procedures/thresholds that will be used to determine whether someone is included or excluded (e.g., "subjects who may be pregnant based on a positive pregnancy test").

1. Inclusion Criteria:

There are no major inclusion and exclusion criteria. No special consideration is given to gender, age, or race during the screening procedures or at any other time. The teacher screening procedures described above mean to ensure that the teachers have the minimum skills required to succeed in the GlobalEd 2 simulation. All teachers that complete the GlobalEd 2 training workshop will be eligible to participate in the implementation of the three stages of the simulation in their social studies classrooms.

Teachers will be recruited based on the following criteria:

- One year at current position teaching Social Studies
- Teaching at least one section of social studies to 7th or 8th graders
- Basic technology skills: email, Internet use
- Internet access (in classroom or lab)
- Availability for professional development (up-front and fall ongoing)
- Availability for participation in the implementation of the GlobalEd 2 simulation

2. Exclusion Criteria: **No special consideration is given to gender, age, or race during the screening procedures or at any other time. The screening procedures described above mean to ensure the participants have the minimum skills required to succeed in the GlobalEd 2 simulation.**

3. Who will assess potential subjects and determine their eligibility for the research? **The PI's.**

4. How will initial eligibility be documented? **Eligibility will be documented in consultation with school administration and through email communication with the teachers.**

5. How will the subjects be monitored during the course of the research to ensure that they still meet the eligibility criteria and how will their continuing eligibility be documented? **Given the nature of the eligibility criteria, teachers need only to meet the criteria when entering the project. The only way in which they would no longer meet the criteria would occur if they stopped teaching.**

F. Equitable Selection of Subjects

Federal regulations require that the selection of research subjects be equitable in order for the IRB to approve the research. If a particular population will be excluded (for example: pregnant women or non-English speaking subjects), you must JUSTIFY the exclusion of this population. NOTE: This question does not refer to clinical trial exclusion criteria, unless entire populations are excluded (for example: if the research is targeting African Americans, Hispanics, or children).

☒ No subjects will be excluded based upon sex, race/ethnic group, or religion.

☐ The following population of subjects will be excluded from the research:

Justification for exclusion:

G. Will any portion of the research involve deception?

☒ No ☐ Yes If YES, complete and submit Appendix J with this application.

XII. Research Subject Population

A. Subject Population

1. Requested number of subjects: Total UIC: For Study 3 in 2019, up to 12 public school teachers in Chicago Public Schools and surrounding suburban county schools. (including JB VAMC subjects)
2. Total non-UIC: **For study 3 in 2019, up to 12 public school teachers in Connecticut public schools**
3. GRAND TOTAL (UIC + non-UIC): **For Study 3 in 2019, a total of 18 public school teachers between both sites.**
4. ☐ Not applicable; this is a Master, Training, or Development protocol and no subjects will be enrolled

Note: The total number stated here will be the total number of approved subjects and will appear in the approval letter. If you are only extracting and/or analyzing case data, and not recruiting subjects, this number will represent the number of cases you are analyzing. This is a specific number and you must not exceed this number. To increase the approved sample size, an amendment must be submitted and IRB-approved prior to recruiting and consenting, or accessing the case data for, more than the approved number of subjects. If the research includes screening procedures that may cause the subjects to be withdrawn after initial recruitment, be sure to provide sufficient numbers to account for screening failures and other reasons for study attrition (such as incomplete or flawed data).

B. Age Range (check all that apply):

☒ Newborn to 17 years of age*
☒ 18-64 Years
☐ 65+ Years
*Submit Appendix B

C. Indicate which populations below are the PRIMARY FOCUS of this research. Remember to take into account the location in which recruitment will occur and where the research will be conducted. Also note that additional information and/or safeguards will be required, as indicated below, when a subject population has been designated as vulnerable (with an asterisk *).
Check all that apply:

☒ Adults: Healthy Subjects or Control Subjects
☐ Adults: Patient Subjects
☐ Pregnant Women, Neonates, Fetuses/Fetal Tissue – *Appendix U must be included **
☐ Prisoners – *Appendix C must be included**
☐ UIC Employees*
☐ UIC Students*

☐ UIC Psychology Student Subject Pool* - *please see OPRS or Psychology Department website for policy*
☐ Decisionally-Impaired* - *Appendix V must be included* *
☐ Economically and/or Educationally Disadvantaged*
☐ Vulnerable to Coercion or Undue Influence*
☐ Other: specify

D. Please note the groups listed directly above marked with an asterisk (*), as well as subjects under the age of 18, are considered "vulnerable" and require special consideration by the federal regulatory agencies and/or by the UIC IRB. If vulnerable populations will be recruited as subjects, **the appropriate Appendixes (indicated above) must be attached to this application. Illinois State Law does not allow prisoners to participate in biomedical research.** Provide a rationale and justification for the inclusion of each vulnerable population indicated above as a primary focus of the research. **N/A**

E. Indicate the location of the subjects at the time the research will be conducted. If data/records pertaining to subjects will be studied, indicate the location where these materials will be when they are accessed or used for the research (for example: if medical records will be accessed and stored at the JBVAMC, JBVAMC should be checked).
Check all that apply:
☐ Subject's home
☐ UICMC
☐ Other UIC locations: specify
☐ JBVAMC
☐ Other hospitals: specify
☐ Community clinic: specify
☐ Other institutions: specify
☐ Other non-institutional settings: specify
☒ Elementary schools: specify – *please see Chicago Public Schools website for policy*

☐ Secondary schools: specify – *please see Chicago Public Schools website for policy*
☐ Other: specify

XIII. Reasonably Anticipated Risks and Benefits of the Research

A. Identify all the reasonably anticipated risks or discomforts that may result from participation in this research (actual and reasonably possible, current and future) and describe the expected frequency, degree of severity, and potential reversibility of those risks (if known). Remember that risks can be psychological, physical, social, economic, or legal. If any portion of the research involves review of medical records, the potential for loss of privacy or confidentiality of health information should be listed as a risk. Please note the risks listed here should correspond to the list provided in the lay summary and the informed consent document.

We believe there are no known risks associated with this research study; however, a possible inconvenience may be the time it takes to complete the study.

B. Please identify the potential for benefits from the conduct of this research. Please note, there must be an expectation of benefit, either directly to subjects or indirectly from the potential knowledge to be gained, in order for the IRB to approve the research. In addition, please note that anticipated risks must be reasonable in light of the potential benefit to be gained.

Through this study we hope to be able to test the efficacy of GlobalEd 2 and systematically investigate factors related to how teachers can build upon the interdisciplinary nature of social studies as an expanded curricular application to increase instructional time devoted to science and persuasive writing in seventh or eighth-grade classrooms. Teacher participants may or may not benefit directly from this study. At the very least, teachers will learn more about science, writing, and problem-based learning and get access to a variety of teaching materials and resources through our workshop.

C. Indicate how the knowledge gained from the study could produce a benefit to society or to others who share the same disorder or condition. State this here and in the consent document.

N/A

D. Please indicate whether there are potential benefits related to an experimental treatment that are only available in the context of the research. State this here and in the consent documents.

N/A

XIV. Research Procedures to Minimize Risk

A. Please indicate the proposed measures to minimize the possibility of undue influence on potential subjects (for example: how will you maximize the subject's autonomous decision-making?)

To prevent coercion of teachers by research staff, principals or districts, teachers are educated on informed consent at the beginning of the study. The informed consent process emphasizes the voluntary nature of participation and the ability to withdraw at any time. We obtain agreements of participation from teachers and principals at the beginning of the project to prevent any appearance of coercion by the principal or district. Additionally, we separate the up-front and fall ongoing professional development, so if teachers change their mind and decide to not participate in fall, they can change their mind and be compensated for the work they have already completed. For the research aspects of the project, teachers are informed that each questionnaire is answered on a voluntary basis and may skip any question they do not wish to answer. Teacher participation is voluntary at all times.

In order to ensure that students are not coerced by teachers to participate in this project, the data collection and assent/consent process is managed by staff. The curriculum elements of the project are not considered research and all students will participate regardless of consent/assent. The data collection associated with the project is considered research and is voluntary. Students are informed that the research element of the project is voluntary and that they can withdraw their participation at any time. Voluntary participation in the research element of the project is emphasized in the student assent and parental consent documents. Students declining to participate in the research component of this study will not participate in any of the research surveys and will not be observed. However, they will complete the educational components of the project as part of their social studies curriculum conducted by their teacher. The following language is also included in the parent consent document, as well as a modified version in the child assent document: 'Your child does not have to be in this study if you do not want him/her to participate. If you give permission for your child to be in the study, but later change your mind, you may withdraw your child from the research component of the project at any time. There are no penalties or consequences of any kind if you decide that you do not want your child to participate. The grades of your child will be unaffected if s/he withdraws from the project. Please note that as your child responds to the questionnaires, s/he does not have to answer any question that he/she does not want to answer. This statement will be clearly explained at the beginning of each questionnaire. Also, your child is allowed to choose to participate in all GlobalEd 2 components, but be excluded from any videotaped recording.'

B. Describe the precautions taken to protect subject privacy during the initial identification of subjects, subject recruitment, and collection of data from the subjects (for example: what precautions will be taken to protect the subject from being recognized as a research subject if recruitment or data collection occurs in a group setting or in public?).

There is no group setting for recruiting teachers. Recruitment communications happen privately and confidentially with the project staff. Students' participation in the

GlobalEd 2 curriculum will be conducted during regular educational time in their classroom. Only data from students who have provided both assent and parental consent will be saved and used for research purposes. Any data of students who do not have both an assent and parental consent on file will be destroyed.

C. Describe provisions you will make to maintain the confidentiality of the research data. Please begin by clarifying the following:

1. Where will the data be stored and what protections will be in place for data security (for example: stored in a locked file cabinet, use of password protected files on computer, data coded such that no direct subject identifiers are on data sheets)?
2. **The following procedures will be used to protect the confidentiality of the data. The researchers will keep all study records (including any codes to the data) locked in a secure location. Research records will be labeled with a code. A master key that links names and codes will be maintained in a separate and secure location. All electronic files (e.g., database, spreadsheet, etc.) containing identifiable information will be password protected. Any computer hosted files will also have password protection and encrypted hard drives to prevent access by unauthorized users. Only the members of the research staff will have access to the passwords. Data that will be shared with others will be coded as described above to help protect the identity of the participants, but the key not released to anyone outside of the key research personnel. An any time during or after the study, the researchers may publish their findings. Information will be presented in aggregate form and will not provide any identifiable information in any of the publications or presentations.**

2. Other than the PI and key research personnel, please indicate below any individuals (for example: collaborators, school officials, medical personnel), organizations, or groups (e.g., study sponsor or CRO), including state and federal auditors, who may have access to identifiable information (consent documents, financial records, case report forms, etc.), including any raw* research data.

   Only the members of the research staff will have access to the raw data and its identifiable information.

**Raw data is the research data in its original form, before any manipulation or "cleaning," and in its original format (e.g. source documents, surveys, data print-outs). Generally the data may be identifiable at this stage.*

Specify any state or federal agencies you know will have specific rights to access this information (for example: FDA, NIH, NCI, Auditors from UIC or the State of Illinois, Government Accounting Office [GAO] for VA research), and include this information in the consent document and appendix H, if applicable. If you are aware of no additional groups having rights to access this information, please indicate so in the space below.
Please note: The UIC OPRS/IRB and Auditors from UIC or the State of Illinois always have the right to inspect research records for research conducted at UIC. Although that is understood and it is not necessary to list them here it is necessary to list these entities in the consent document and the HIPAA authorization documents. All other entities listed in this section must also be listed in the confidentiality section of the consent document and the HIPAA authorization document.

3. Indicate why the individuals, organizations, or groups identified in 2 above will be provided access to the research data and indicate how they will be given access.

   Only the members of the research staff will have access to the raw data and its identifiable information.

4. Describe any procedures for sharing research data.

   During and after the study, the researchers may publish their findings. Information will be presented in aggregate form and will not provide any identifiable information in any of the publications or presentations.

5. Will the research data be coded to protect the identity of the subject when shared?

   Yes Information would be presented in aggregate form and it would not provide any identifiable information. Yes, all research data will be coded and aligned with a master key, which is stored in a different location than the data. When shared or applied to research presentations, all information will be presented in aggregate form and would not provide any identifiable information.

6. Will the data be de-identified or destroyed? ☒ Yes ☐ No

   If YES, explain how and when this will occur: **The master key and audio/video tapes produced from any interviews and observations will be destroyed after 3 years.**

   The consent document must describe if and how the date will be de-identified or destroyed, or if identifiers will be maintained.

D. Describe provisions you will make to maintain the security of stored or banked research data. Please begin by clarifying the following:

1. Will any biological samples or specimens be stored, even temporarily, as a result of the research?

   ☒ No ☐ Yes **If YES,** complete and submit Appendix D1 with this application packet.

2. Will any identifiable data, or coded data where a master list to the codes exists, be stored or entered into an existing databank as a result of the research?

   ☒ No ☐ Yes **If YES,** complete and submit Appendix D2 with this application packet.

E. Please describe any provisions for providing medical care to subjects in case of an accident, injury, or complications related to the research procedures. **Given the nature of this research, no medical care provisions will be necessary.**

Please note: If the research involves no more than minimal risk, this portion of the consent document/application may not be applicable.

1. Is the language explaining provisions for medical care in the consent document?
   ☒ No ☐ Yes

F. Does the research protocol have a data and safety monitoring plan? ☒ No ☐ Yes

> Please note: NIH policy requires that some grantees, including all those using the CRC, have a data and safety monitoring plan which has been reviewed and approved by the IRB. The data and safety monitoring plan may include the establishment of a Data Safety Monitoring Board (DSMB) or Data Monitoring Committee (DMC).

1. **If YES**, please describe the data safety monitoring plan in detail here:

   If NO, please describe the methods to be used in this study to monitor the ongoing safety of the subjects (for example: sponsor medical monitor, AE reporting, protocol specific safety features like stopping rules, etc.).

2. Will there be a data safety monitoring board (DSMB)/ Data Monitoring Committee (DMC) assigned to this study? ☒ No ☐ Yes
   If YES, describe the DSMB/DMC structure and meeting plan (for example: how often they will meet) and how the findings will be reported back to the individual investigators and the IRBs.

3. Is this a multi-center trial AND is UIC and/or JBVAMC the lead site or serving as the data coordinating center? ☒ No ☐ Yes
   If YES, describe the plan for managing and communicating the following information among the multi-center sites:
   - Unanticipated problems involving risks to subjects or others
   - Interim results
   - Protocol modifications

G. Will you be applying for a Certificate of Confidentiality? ☒ **No** ☐ **Yes**

If YES, please include this information (as well as any exceptions — for example: mandatory reporting, threats of self-harm) in the consent document. When the IRB approves your research, submit a request for a Certificate of Confidentiality to the appropriate federal agency. After you receive the Certificate of Confidentiality, you must submit an Amendment to the IRB and receive IRB approval. Research subjects may only be enrolled after IRB approval of the Amendment and Certificate of Confidentiality. Please refer to the section on Certificate of Confidentiality on the OPRS website:
http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/index.shtml

XV. Recruitment of Subjects

A. How will potential subjects be initially identified for this research study?

☐ Own Clinical Practice (face to face) ☐ Psychology Student Subject Pool

☐ Registry or bank (either specimens or data) ☐ Records (e.g.: medical, employment, school)

☒ Subject responding to flyer or other advertisement ☐ Other: specify

B. Initial Contact

Indicate who will make the initial contact with the potential subjects for the purpose of recruiting them for the research.

☒ Principal Investigator ☐ Research Coordinator ☐ Co-Investigator

☐ Other Key Research Personnel – specify:

C. Describe how, where, and when subjects will be recruited for the research **We will leverage our school-based connections cultivated from previous and current school-based projects across our two sites (e.g., The TNE Project, Project Titus at UIC, The UIC Digital Literacy Project, The UConn Urban Initiative) in order to recruit the social studies teachers from Connecticut and Ullinois. Additionally, we will be using our respective university relationships with professional development schools and districts to solicit social studies teachers and school districts to participate. We are not yet aware of the exact schools that we will be contacting. An email will be sent out to social studies teachers. Teachers interested in this opportunity will contact the principal investigator (see recruitment email).**

After teachers make initial contact with the principal investigator from the recruitment email or informational flyer, additional informational contacts will be made by GlobalEd 2 project staff to assess eligibility and to provide information about the project.

Contact 1: If a teacher contacts the project staff, the staff will contact the teacher with additional information in GlobalEd 2 (e.g., flyers and graphics about the project). This email will follow *Teacher Recruitment Acknowledgement Email v.1*, which is a new document and being included in this revision to this application.

Contact 2: If teachers are still interested after Contact 1, a telephone call will be conducted with project staff to determine eligibility and share information about the project. Because this is a professional-to-professional conversation, we do not have a hard script for this phone call. Instead, we will use a bulleted list of prompts which is an outline of points that will be addressed during the conversation. The document *Teacher Eligibility and Information Discussion v.1* is used to guide this phone call. This is a new document and is being included in this revision to this application. At this point, there will be no documentation of eligibility. If the teacher is found to be eligible during the conversation, the conversation continues. If the teacher is not eligible, they are thanked and the conversation ends.

Students and parents will be recruited through teacher participation. Students are selected for participation by nature of being in a participating teacher's class. At the beginning of the project, researchers will provide each student with an opportunity to complete an assent form. For students whose native language is not English, a translated form will be provided in their primary language. Students are not obligated to consent and participate in the research, and will not have an adverse effect on their grades or other performance in class. Parents of students will also have an opportunity to consent to their child participating in the research project. Students will receive consent forms to take home and have their parents complete. The consent forms will outline the research project, procedures, the data to be collected, and known risks. Parents are not obligated to consent to the project. For a student's data to be used in the study, both the student and parent must assent or consent to participation in the study.

Please note that recruitment of subjects at JBVAMC must not occur until approved by the JBVAMC R&D Committee.

D. Recruitment Materials

Check all materials that will be used for recruitment. See the UIC requirements for recruitment materials available on the OPRS web site: (http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0233.pdf).

☐ No recruitment materials will be used	☐ Mass Mailing
☐ Ad (print)	☐ Physician letter
☐ Ad (radio-provide script, then tape)	☐ Patient letter
☐ Ad (TV- provide script, then video)	☐ Physician referral
☐ Internet – UIC	☐ Telephone script (for response to ad)
☒ Internet – Other	☐ Recruitment script (to aid in consent process)
☒ Information sheets (before study)	☐ Brochure
☐ Information sheets (during study)	☐ Flyer
☒ E-mail notice	☐ Other: specify

E. Compensation

Please see the OBFS website for guidelines regarding payment options (for example: cash, gift cards, etc.) and OBFS documentation required for payment to subjects http://www.obfs.uillinois.edu/manual/central_p/sec8-10.html#dd.

1. Will subjects receive any compensation (for example: money, gifts, or gift certificates) before, during, or after participation in the study?
   ☐ No **If NO,** please go to number 4.
   ☒ Yes. **If YES**, please indicate the type of compensation. Please note: This information must be outlined in the consent document.
   ☒ Monetary (total amount: $1200 – teachers (for professional development and participation in research activities) ☐ Non- Monetary ☐ Both
2. If compensation will be given, please describe whether it is compensation for travel expenses, for time, for both, or for something else

   ☐ For travel expense ☐ For time ☒ For both ☐ Other:
3. Describe in detail how and when compensation will be provided: **Compensation will be provided at the completion of each phase of the project, only when each phase is completed in full: Phase 1 – up-front, self-paced professional development workshop (before implementing GlobalEd 2 in the fall); Phase 2 – ongoing professional development and participation in research activities (fall 2017).**

a. Will subjects be compensated per session/task and/or will their compensation be pro-rated?

☐ No ☒ Yes

b. **If YES,** please provide detail regarding the compensation per session/task and/or proration schedule:

Teachers will be provided a $300 stipend for participating in the up-front PD workshop. Teachers will be compensated if they complete all modules of the workshop (this information will be stated in their consent documents).

They will also receive a stipend of $900 for participating in ongoing professional development over the course of the fall. The ongoing professional development will be to support their implementation of all three phases of the GlobalEd 2 simulation in their classroom.

4. List what research-related expenses a) are provided for free and b) are not being covered by the research (e.g., research-related procedures, additional clinic visits, longer hospitalization period or extra tests related to the research). Include estimated amounts for any expenses not being covered, if possible: **Any additional expenses are unknown.**

Please note: This information must also be included in the cost section of the informed consent document.

XVI. Procedures to Obtain Informed Consent/Assent

Please indicate all of the types of consent processes to be used in the research, and submit copies of all relevant documents with this application.

☒ Prospective Written Informed Consent
☐ Waiver of Informed Consent
☐ Waiver of Documentation of Consent
☐ Alteration of Consent
☐ Waiver of Assent
☐ Parental Permission*
☐ Waiver of Parental Permission*
☐ Assent – Written*
☐ Assent – Verbal*

* Submit Appendix B or Appendix V

A. Please indicate whether the Principal Investigator will personally perform the consent process, including the documentation of informed consent and/or assent, or whether the PI will retain responsibility for overseeing this process but delegate the authority to perform these duties to others:

☐ Only the PI will obtain consent ☒ PI and Delegates will obtain consent
☐ Only Delegates will obtain consent

If the PI will allow delegates to obtain informed consent, please submit a list of individual delegate names, or delegate titles, of who will be designated to obtain consent. Please note that these persons must be listed as Key Research Personnel and include a description of the training that these persons will complete prior to their participation in this research.

Kamila Brodowinska Bruscianelli, Research Associate (UIC), IRB Training Completed

James Oren (UIC), Research Assistant, IRB Training Completed

Jeremy Riel (UIC), Research Specialist, IRB Training Completed

B. Please indicate whether informed consent will be obtained using procedures and documents in a language understandable to the subject and/or the parent, guardian or LAR.

Please note that a "short form" and translation process may be used when the enrollment of a limited number of non-English speaking subjects **could not reasonably have been anticipated** and a fully translated consent document is not available. For information about the short form, please refer to the OPRS website at: http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/index.shtml. **Prior IRB approval is required before enrollment of a subject who speaks a language that was not anticipated by the protocol.**

C. Please identify where and when informed consent will be obtained from potential subjects.
Participants will be asked to consent before they participate in the summer workshop at each of the participating sites.

D. Please discuss whether there will be any waiting period between informing the prospective subject and obtaining consent, (e.g., does the research require consenting of potential subjects in the ER immediately after diagnosis of an MI or a terminal illness?).
No

XVII. Request for Waiver of Consent, Alteration of Consent, or Waiver of Documentation

An IRB may (1) approve a consent process that does not include, or alters, some or all of the elements of informed consent, or (2) the IRB may waive the requirement to obtain written consent (called a waiver of documentation), or (3) the IRB may waive the requirement to obtain informed consent entirely. In order to make these determinations, the IRB must ensure that the Federal requirements for each waiver/alteration criterion are met and justified for the specific research protocol.

A. Are you requesting a waiver of informed consent or an alteration of consent under 45 CFR 46.116 (d) for all or part of the research? ☒ No ☐ Yes

If YES are you requesting a:
☐ Waiver for all of the research ☐ Waiver for recruitment purposes ☐ An alteration of consent

If a waiver or alteration is not being requested, then please proceed to question D below in the application.
If you are requesting a waiver or alteration of consent, proceed to question B below. If you are requesting an alteration, also complete question C.

In order to apply for a waiver or alteration of consent, you must provide protocol specific justification for the four following criteria. A waiver may be requested for the entire study or for only one portion of the research (for example: a waiver of informed consent is requested to identify potential research subjects from medical records, but informed consent is still be required for the later enrollment of the subjects for research participation – called a waiver for recruitment purposes). ***NOTE:*** *If you are requesting a waiver of consent and accessing PHI, a waiver of authorization is probably also required.*

B. 1. Please provide a written explanation as to why you believe the proposed research (or portion of the research) will present no more than minimal risk to the subjects who participate:
n/a

2. Please explain whether or not a waiver or alteration of informed consent would adversely affect the rights and welfare of subjects:
n/a

3. Please explain whether or not it would be possible to conduct this research without a waiver or alteration of informed consent:
n/a

4. Please explain your plans, when appropriate, for providing any pertinent information to the subjects at a later date (e.g., after their participation in the study):
n/a

C. If you are requesting an alteration of consent, please describe in detail how you wish to alter the consent process and justify the need for this alteration.
n/a

Please note: Waiver of consent, alteration of consent, and waiver of documentation are all separate processes. For additional information, please refer to the OPRS website at *http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/index.shtml*

D. Are you requesting a waiver of documentation of informed consent under 45 CFR 46.117 (c)?

☒ No ☐ Yes

If YES, please indicate which of the following justifications is being used to request a waiver of documentation and then provide protocol specific justification for the waiver under either criteria:

☐ The only record linking the subject and the research would be a signed consent document, the principal risk or harm of the research would be a breach of confidentiality, and each subject will be asked whether they want documentation linking themselves and the research and the subject's wishes will govern.
Explanation:

☐ The research involves no more than minimal risk or harm to the subject and involves no procedures for which written consent is normally required outside of the research context.
Explanation:

If documentation of informed consent is waived, the IRB may require the investigator to provide subjects with a written statement regarding the research, which contains all the elements of informed consent. Please provide such a written document for review and label it "Subject Information Sheet". Be sure that the document has a footer with version number and date.

XVII. CONTACT INFORMATION

Who should be the primary person contacted (for example, Research Coordinator) by OPRS if further information about this protocol is needed? This person may be someone other than the PI or other individuals listed as key research personnel (i.e., Administrative Coordinator).

Do you wish to grant this individual RiSCWeb access to this research protocol?

☒ Yes ☐ No

Name (Last, First)		Title
Riel, Jeremy		**Research Specialist**
E-mail Address		Date
jriel2@uic.edu		**06/18/2017**
Phone Number	Fax Number	
541-513-1293	**n/a**	

Do you agree to have this research listed on the UIC research directory (web page)?

☒ No ☐ Yes

If YES, please submit the following:

Title:
Investigator Name:
Three (3) Keywords describing the research:
Contact Information for further information (if different from contact information given immediately above):

INVESTIGATOR ASSURANCE

I certify that the information provided in this application is complete and correct. I understand that as Principal Investigator, I am ultimately responsible for the protection of the rights and welfare of human subjects and the ethical performance of the research. I agree to comply with all applicable UIC policies and procedures, and applicable federal, state and local laws. I also agree to the following:

- The research will only be performed by qualified personnel as specified in the approved research application and/or protocol,
- No changes will be made to the research protocol (except when necessary to eliminate apparent immediate hazards to the subject), or the consent process (if one is required) without prior approval by the UIC IRB,
- Legally effective informed consent/assent will be obtained from all human subjects, unless this requirement is waived by the UIC IRB, using only the recruitment materials and informed consent/assent documents that have been approved by the UIC IRB. The potential benefits of participation will not be overstated and reasonably anticipated risks will not be minimized. Subjects will be asked open-ended questions to try and ensure adequate comprehension of the information so as to allow for truly informed consent to participate.
- Unanticipated problems involving risks to subjects or others (including adverse events), other reportable events, and subject complaints will be reported to the UIC IRB in a timely manner.

I certify that I have completed the required educational program on ethical principles and regulatory requirements in Human Subject Protections. I further certify that the proposed research is not currently underway and will not begin until IRB approval has been obtained.

Principal Investigator Signature _____________________________________DATE____________________

Name printed:____

FACULTY SPONSOR* ASSURANCE

**The faculty sponsor must be a member of the UIC faculty. The faculty member is considered the responsible party for legal and ethical performance of the project.*

By my signature as sponsor on this research application, I certify that the student, fellow, or resident is knowledgeable about the regulations and policies governing research with human subjects and has sufficient training and experience to conduct this particular study in accord with the approved protocol.

In addition,

- I agree to meet with the investigator on a regular basis to monitor study progress,
- Should problems arise during the course of the study, I agree to be available, personally, to supervise the investigator in solving them,
- I will ensure that the Principal Investigator promptly reports unanticipated problems involving risks to subjects or others (including adverse events), other reportable events, and subject complaints to the UIC IRB in a timely manner,
- If I will be unavailable, as when on sabbatical leave or vacation, I will arrange for an alternate faculty sponsor to assume responsibility during my absence and I will advise the UIC IRB by letter of such arrangements, and
- I insure that the investigator has completed the required educational program on ethical principles and regulatory requirements and will complete all required continuing education.
- I further certify that the proposed research is not currently underway and will not begin until approval has been obtained from all the appropriate committees.
- I will ensure that the Principal Investigator submits a Final Report upon completion of the research. In the event that the Principal Investigator is unable to do so, I accept the ultimate responsibility for submission of the Final Report closing the research study.

Faculty Sponsor Signature_______________________________________Date______________

Name printed:____

DEPARTMENT HEAD* SIGNATURE

**If the Department Head is the Principal Investigator or any of the Co-Investigators, the Department Head's superior (for example: Dean), must sign in place of the Department Head.*

As department head (or signatory official), I acknowledge that this research is in keeping with the standards set by our department and I insure that the Principal Investigator has met all departmental requirements for review and approval of this research.

By my signature as department head (or signatory official) on this research application, I certify that the Principal Investigator has the training and expertise to conduct research at UIC and that the research meets the standards of the specific discipline, as well as the standards and guidelines of any relevant professional organizations, societies, or licensing bodies.

Department Head Signature____Date___________

Name printed: ____

VITA

Jeremy Riel

Foci of Research and Development

- Online learning technology design, implementation, and pedagogy
- Simulations, games, and serious play
- Distance-based teacher and college faculty professional development and ongoing learning
- Learning analytics in digital learning environments

Current Position

Project Manager & Lead Technologist **2017 - Present**
GlobalEd - University of Illinois at Chicago – Chicago, IL
- Responsible for research efforts, technology development, and administrative management for GlobalEd, a national, social studies, blended learning simulation game and curriculum for middle school. (www.globaled2.com)
- Develop and manage ongoing simulation games for use in classrooms, student instructional technology, teacher professional development initiatives, and technology assets. Plan, conduct, lead, and disseminate research publications for the project.

Education

University of Illinois at Chicago – *Chicago, IL* **2012 – 2020**
- **Ph.D.**, Educational Psychology
- Dissertation: "*Measuring Feature-Level Participation and Efficacy with Online Teacher Professional Development (oTPD)*." March 2020.
- Research foci in educational technology, distance learning, simulations and games, and teacher professional development.

Georgetown University – *Washington, D.C.* **2010 – 2012**
- **M.A.**, with distinction, Communication, Culture, and Technology (CCT)
- Thesis: "*The Digitally Literate Citizen: How Digital Literacy Empowers Mass Participation in the United States*." May 2012.
- Activities and memberships:
  - Apprenticeship in Teaching Program

University of Oregon – *Eugene, OR* **2005 – 2007**
- **B.A.**, cum laude with departmental honors, Political Science
- Professional Distinction certificate in Written Communication
- Activities and memberships:
  - Phi Beta Kappa, Pi Sigma Alpha Political Science Society, Golden Key

Lane Community College – *Eugene, OR* **2003 – 2005**
A.A., Lower Division Oregon Transfer Degree; Phi Theta Kappa Society

Previous Employment

Coordinator **2012 – 2017**
FACT: Faculty Assistance Center for Technology
College of Education, University of Illinois at Chicago – Chicago, IL

- Coordinate a university center that provides professional development programs and workshops related to educational technology for college faculty, staff, and pre-service teachers.
- Consult with faculty and staff one-on-one on strategies for integrating technology into teaching and college operations and curate a college web resource library.

Graduate Research Assistant **2012 – 2017**
University of Illinois at Chicago – Chicago, IL

- 2013 – 2017: **GlobalEd** – project technologist and instructional designer. URL: www.globaled2.com
- 2012 – 2013: **American Migrations Project** – instructional designer.

Principal **2009 – 2015**
Millennial Associates LLC – Springfield, OR & Chicago, IL

- Technology consultancy on digital learning and technology trends in higher education.

Graduate Teaching Assistant **2011 – 2012**
Georgetown University – Washington, D.C.

- CCTP 506 *Fundamentals of Technology. 2012.*
- CCTP 804 *Advanced Statistical Methodology.* 2012.
- CCTP 771 *Statistical Methodology. 2011.*

James H. Dunn Fellowship **2007 – 2008**
State of Illinois – Chicago, IL

- Legal and legislative research fellow, Office of the Governor.

Legislative Research Intern **2007**
Representative Phil Barnhart, Oregon State House of Representatives – Salem, OR

- Researched pending legislative education issues and policies.

Undergraduate Research Assistant **2006 – 2007**
University of Oregon – Eugene, OR

- Research on technology policy.

Research Assistant **2004 – 2005**
Lane County Commission, Commissioner Peter Sorenson – Eugene, OR

- Researched constituent issues and proposed ordinance/code changes.

Books

Riel, J., Lawless, K. A., & Powell, N. (2020). *GlobalEd CE Community Edition Facilitator's Guide and Base Game Rules – A Simulation Game for Middle and High School Social Studies: Developing Student Skills in Socio-Scientific Understanding, Inquiry, and Information Literacy for Blended and Flipped Classrooms and Remote Learning Classes.* Eugene, OR: Innovations in Instruction.

Riel, J. (2017). *Thinking pedagogically about educational technology trends: Prioritizing teaching and learning activities with 21 popular educational technologies and digital trends from 2016*. Springfield, OR: ETN Press.

Peer-Reviewed Articles and Chapters

Riel, J., & Lawless, K. A. (in review). Enhancing student affect from multi-classroom simulation games via teacher professional development: Supporting game implementation with the ROPD model. *International Journal of Simulations and Game-Based Learning.*

Riel, J., & Lawless, K. A. (in review, invited). MOOCs and self-paced online learning in the 2020 pandemic era: A review of the design features and research of massive online courseware amid global shifts to remote instruction. *International Journal of Hyperconnectivity and Internet-of-Things.*

Lawless, K. A., & **Riel, J.** (2020). Exploring the utilization of the big data revolution as a methodology for exploring learning strategy in educational environments. In D. L. Dinsmore, L. K. Fryer, & M. M. Parkinson (Eds.), *Handbook of Strategies and Strategic Processing*. New York: Routledge.

Riel, J. (2020). Essential features and critical issues with educational chatbots: Toward personalized learning via digital agents. In M. Khosrow-Pour (Ed.), *Handbook of Research on Modern Educational Technologies, Applications, and Management*. Hershey, PA: IGI Global.

Riel, J., Lawless, K. A., & Brown, S. W. (2018). Timing matters: Approaches for measuring and visualizing behaviours of timing and spacing of work in self-paced online teacher professional development courses. *Journal of Learning Analytics. 5*(1), 25-40.

Lawless, K. A., Brown, S. W., Rhoads, C. H., Lynn, L. J., Newton, S. D., Brodowinska, K., Oren, J., **Riel, J.**, Song, S., & Wang, M. (2017). Promoting students science literacy skills through a simulation of international negotiations: The GlobalEd 2 Project. *Computers in Human Behavior, 78,* 389-396. http://doi.org/10.1016/j.chb.2017.08.027.

Riel, J., Lawless, K. A., & Brown, S. W. (2017). Defining and designing responsive online professional development (ROPD): A framework to support curriculum instruction. In Kidd, T. & Morris, L. R. (Eds.), *Encyclopedia of Instructional Systems and Technology*. 104-115. Hershey, PA: IGI Global. http://doi.org/10.4018/978-1-5225-2399-4.ch010.

Riel, J. & Lawless, K. A. (2017). Developments in MOOC technologies and participation since 2012. In M. Khosrow-Pour (Ed.), *Encyclopedia of Information Science and Technology* (4th Ed.). Hershey, PA: IGI Global.

Riel, J., Lawless, K. A., & Brown, S. W. (2016). Listening to the teachers: Using weekly online teacher logs for ROPD to identify teachers' persistent challenges when implementing a blended learning curriculum. *Journal of Online Learning Research*, *2*(2), 169-200.

Riel, J. & Lawless, K. (2015). Massive open online courses (MOOCs) and the technologies that support learning with them. In M. Khosrow-Pour (Ed.), *Encyclopedia of Information Science and Technology* (3rd Ed.). Hershey, PA: IGI Global.

Lawless, K. A., Brown, S. W., Brodowinska, K., Lynn, L., **Riel, J.**, Fields, K., Le-Gervais, L., & Mullin, G. (2014). The GE2 Project – Developing a scientifically literate citizenry. In M. Khosrow-Pour (Ed.), *Encyclopedia of Information Science and Technology* (3rd Ed.). Hershey, PA: IGI Global.

Conference Presentations

Riel, J., & Lawless, K. A. (2020). Effects of online responsive professional development (ROPD) on teachers' implementation adherence of a classroom problem-based learning (PBL) simulation game and curriculum. Presented at the Society for Information Technology & Teacher Education (SITE) 2020 Annual Meeting, Virtual Conference (previously scheduled at New Orleans, LA), April 2020.

Lawless, K. A., & **Riel, J.** (2020). Toward utilizing big data for exploring learning strategy in digital learning environments. Annual Meeting of the American Educational Research Association, April 2020 (Conference Canceled).

Riel, J., Oren, J., & Lawless, K. A. (2020). Implementing serious classroom play: An investigation linking student achievement to teachers' fidelity of implementation of GlobalEd, a classroom-based simulation game. Presented at the 2020 Eastern Educational Research Association Annual Meeting, Orlando, FL, February 2020.

Riel, J., & Lawless, K. A. (2020). Positive effects of online responsive ongoing professional development (ROPD) on teachers' use of a simulation game. Presented at the 2020 UIC College of Education Research Day, Chicago, IL, February 2020.

Lawless, K. A., Brown, S. W., Lynn, L. L., **Riel, J.**, Brucianelli, K. B., & Oren, J. B. (2019). Efficacy of a socioscientific simulation on students' written argumentation. Presented at the 2019 American Educational Research Association Annual Meeting, Toronto, Ontario, Canada, April 2019.

Riel, J., Lawless, K. A., & Brown, S. W. (2019). Differentiation of Ongoing PD to Support Curriculum Implementation Based on Years of Experience: Toward Identifying and Addressing Varied Teacher PD Needs. Presented at the 2019 American Educational Research Association Annual Meeting, Toronto, Ontario, Canada, April 2019.

Lawless, K. A., Brown, S. W., **Riel, J.,** Oren, J., Lynn, L., & Brodowinska, K. (2019). Improving students' written argumentation through socio-scientific inquiry. Presented at the International Conference of Psychological Science, Paris, France, March 2019.

Riel, J., Lawless, K. A., & Brown, S. W. (2019). Opportunities for differentiating ongoing teacher professional development based on years of experience. Presented at the 2019 UIC College of Education Research Day, Chicago, IL, February 2019.

Riel, J., Lawless, K. A., & Brown, S. W. (2018). Examining Path Sequences to Identify Categories of Teacher Informational Website Use during Ongoing Professional Development. 2018 American Educational Research Association Annual Meeting, New York, NY.

Riel, J., Lawless, K. A., & Brown, S. W. (2018). Examining Path Sequences to Identify Categories of Teacher Informational Website Use during Ongoing Professional Development. 2018 University of Illinois at Chicago College of Education Annual Research Forum, Chicago, IL., December 2018.

Brown, S. W., Lawless, K. A., Newton, S. D., Lynn, L., **Riel, J.**, Song, S., & Oren, J. (2018). Increasing Students' Engagement with STEM through a PBL Simulation. Annual meeting of the Eastern Educational Research Association, Clearwater Beach, FL.

Riel, J., Lawless, K. A., & Brown, S. W. (2017). Is anyone watching the course video? Inferring elapsed watch time and video engagement patterns when using embedded videos from YouTube, Vimeo, or other third-party video streaming services for Moodle and other online learning management systems. 2018 EdMedia Conference, Washington, D.C.

Riel, J., Lawless, K. A., & Brown, S. W. (2017). Timing and spacing of work as predictors of confidence in self-paced, online teacher professional development. 2017 American Educational Research Association Annual Meeting, San Antonio, TX.

Oren, J. B., Lawless, K. A., Brown, S. W., **Riel, J.,** Lynn, L. J., & Brucianelli, K. B. (2017). Exploring teachers' facilitative behaviors across implementation years. 2017 American Educational Research Association Annual Meeting, San Antonio, TX.

Riel, J., Lawless, K. A., & Brown, S. W. (2017). Timing and spacing of work as predictors of confidence in self-paced, online teacher professional development. 2017 University of Illinois at Chicago College of Education Annual Research Forum, Chicago, IL.

Wang, M. S., Morassini, M., Newton, S. D., Song, S., Zhao, A., Brown, S. W., Lawless, K. A., Lynn, L., **Riel, J.**, Bruscianelli, K., & Oren, J. (2016). Prior knowledge and scientific literacy: An inspection on the contemporary knowledge sources and effects on scientific writing. 6th International Symposium on Society, Education, and Psychology (ISSTEP 2016), Beijing, China.

Wang, M. S., Morassini, M., Newton, S. D., Song, S., Zhao, A., Brown, S. W., Lawless, K. A., Lynn, L., **Riel, J.**, Bruscianelli, K., & Oren, J. (2016). Capitalizing on students' prior knowledge to improve scientific writing proficiency. 2016 APS Convention, Chicago, IL.

Song, S., Newton, S. D., Wang, M. S., Morassini, M., Zhao, A., Brown, S. W., Lawless, K. A., Lynn, L., **Riel, J.**, Bruscianelli, K., & Oren, J. (2016). The influence of gender and internet access on academic self-efficacy in middle school students. 2016 APS Convention, Chicago, IL.

Riel, J., Lawless, K. A., & Brown, S. W. (2016). Completion, time-in-intervention, and movement: Relationships between dimensions of participation in oTPD and knowledge. 2016 American Educational Research Association Annual Meeting, Washington, D.C.

Oren, J. B., Lawless, K.A., Brown, S. W., Brucianelli K. B., **Riel, J.**, & Lynn, L. J. (2016). Do teachers' behaviors change while leading a collaborative classroom? 2016 American Educational research Association Annual Meeting, Washington, D.C.

Lawless, K. A., Brown, S. W., Lynn, L. J., Brucianelli, K. B., **Riel, J.**, & Oren, J. B. (2016). Improving written argumentation through web-based, interdisciplinary simulations: The GlobalEd 2 Project. 2016 American Educational Research Association Annual Meeting, Washington, D.C.

Brucianelli, K. B., Lawless, K. A., Brown, S. W., Zhao, A., Oren, J., **Riel, J.**, & Lynn, L. J. (2016). Examining differences among teacher implementation patterns. 2016 American Educational Research Association Annual Meeting, Washington D.C.

Riel, J., Lawless, K. A., & Brown, S. W. (2016). Completion, time-in-intervention, and movement: Relationships between dimensions of participation in oTPD and knowledge. 2016 University of Illinois at Chicago College of Education Annual Research Forum, Chicago, IL.

Brown, S. W., Lawless, K. A., **Riel, J.**, Wang, M., Lynn, L., Newton, S., Brucianelli, K., Zhao, A., Song, S., & Oren, J. (2015). Promoting STEM literacies and attitudes in students through an online problem-based learning simulation of international negotiation. 2015 Hawaiian International Conference on Education, Honolulu, HI.

Riel, J., Lawless, K. A., Brown, S. W., & Lynn, L. J. (2015). Teacher participation in ongoing online professional development to support curriculum implementation: Effects of the GlobalEd 2 PD program on student affective learning outcomes. Proceedings of the 2015 Annual Meeting of the Society for Information Technology and Teacher Education, Las Vegas, NV. Waynesville, NC: SITE.

Lawless, K. A., Brown, S. W., Lynn, L. J., Brodowinska, K. B., **Riel**, **J.**, Fields, K., Dye, C., Le, L., Lin-Steadman, P., & Alanazi, R. (2015). GlobalEd 2: A problem-based, interdisciplinary simulation targeted at written argumentation. American Educational Research Association. Chicago, IL.

Brown, S. W., Lawless, K. A., Lynn, L. J., Brodowinska, K. B., & **Riel, J.** (2015). Promoting science knowledge through an educational game: GlobalEd 2. 2015 American Educational Research Association Annual Meeting, Chicago, IL.

Lynn, L. J., Lawless, K. A., Brown, S. W., Brodowinska, K. B., **Riel, J.** (2015). Socioscientific conceptual change in an online problem-based learning scenario. 2015 American Educational Research Association Annual Meeting, Chicago, IL.

Field, K., **Riel, J.**, Lawless, K., Brown, S., & Brodowinska, K. (2014). Supporting successful implementation of a PBL curriculum: Scaffolding and research skills. 2014 Northeast Educational Research Association Annual Conference, Trumble, CT.

Riel, J., Lawless, K., & Lynn, L. (2014). Teacher participation in ongoing professional development using email newsletters and teacher journaling: The GlobalEd 2 online professional development program. University of Illinois at Chicago College of Education Annual Research Forum, Chicago, IL.

Lawless, K. A., Brown, S. W., Brodowinska, K., Field, K., Lynn, L., **Riel, J.**, Le-Gervais, L., Dye, C., & Alanazi, R. (2014). Expanding the science and literacy curricular space: The GlobalEd2 Project. Annual Meeting of the Eastern Educational Research Association, Jacksonville, FL.

Radinsky, J., Hospelhorn, E., Melendez, J., & **Riel, J**. (2013). What should we teach with historical census data visualizations? An examination of learning objectives for classroom GIS projects studying African American and Latino migrations. 38th Annual Meeting of the Social Science History Association, Chicago, IL.

Lawless, K. A., Brown, S. W., Brodowinska, K., Lynn, L. **Riel, J.**, Lee, L, Mullin, G., & Maneggia, D. (2013). Using digital communications to create a scientifically literate citizenry – The GlobalEd 2 Project. University of Illinois at Chicago College of Education Research Day, Chicago, IL.

Riel, J., Christian, S., & Hinson, B. (2012). Charting Digital Literacy: Digital literacy, the community college, and student success. 2012 Innovations Conference, League for Innovation in the Community College, Philadelphia, PA.

Invited Presentations and Talks

Riel, J., & Lawless, K. A. (2020). GlobalEd Community Edition (CE): A simulation game for use in social studies classes for remote learning. Social Studies Virtual Unconference. U.S. Department of Education, Institute of Educational Sciences. Online, May, 2020.

Lawless, K. A., & **Riel, J.** (2020). Demonstration of the GlobalEd Online Simulation Game: The Mediterranean Sea Oil Spill Scenario. U.S. Department of Education IES Ed Games Expo – Benjamin Tasker Middle School, Bowie, MD, January 2020.

Lawless, K. A., **Riel, J.,** & Brown, S. W. (2019). Demonstration of the GlobalEd Online Simulation Game: The Mediterranean Sea Oil Spill Scenario. U.S. Department of Education IES Ed Games Expo, HD Woodson STEM High School, Washington, D.C., January 2019.

Riel, J., Lawless, K. A., & Brown, S. W. (2016). Listening to the teachers through journals and ROPD: The need for identifying teacher challenges as they happen and providing responsive online professional development. Michigan Virtual Learning Research Institute Webinar Series. October, 2016.

Riel, J. (2013). Knowledge sciences, knowledge technology, and learning. 2013 Invitational Knowledge Sciences Symposium, September 2013, Washington, D.C.

McCown, T. & **Riel, J.** (2013). Empowering faculty with open education resources. League for Innovation in the Community College Learning Summit, Chandler, AZ.

Professional Development Programs Designed & Facilitated

- *"Identifying Curricular Alignment and Opportunities for Classroom Balance with the GlobalEd Online Simulation."* Online, multi-state, June-August, 2019.
- *"Encouraging Ongoing Student Engagement with the GlobalEd Online Simulation."* Online, multi-state, June-August, 2018.
- *"Addressing Persistent Classroom Challenges with the GlobalEd Online Simulation Game."* Online, multi-state, June-August, 2017.
- "Planning and Facilitating an Online Simulation with Your Class for a Full Academic Year: Making the Most Out of a Year With GlobalEd." Online, multi-state, June-August, 2016.
- *"Citation Management Software: Using Mendeley to Stay Sane When Organizing Your Research."* University of Illinois at Chicago, College of Education, October, 2015.
- *"Let's Play Again: Teaching with the GlobalEd Online Simulation for the Second Time Around and Gaining Insights from First-Time Play."* Online, multi-state, June-August, 2015.
- *"Online Collaborative Document Making and Team Cloud-Based Storage: Getting the Most Out of Box, Dropbox, Google Apps, and Office 365 for Teaching and Research."* University of Illinois at Chicago, College of Education, April, 2015,
- *"Beginning with the GlobalEd simulation and facilitating Online Simulation Games."* Online, multi-state, June-August, 2014.
- "*So what goes into an online class, anyway?*" University of Illinois at Chicago, College of Education, February, 2014.

- "*Get your head in the cloud! Demystifying the "cloud" and how cloud-based apps can help your research, teaching, and service.*" University of Illinois at Chicago, College of Education. November, 2013.
- "*Old data, new tricks: Leveraging web-based data visualization and analysis tools to creatively present and see data in new ways*." University of Illinois at Chicgao, College of Education. October, 2013.
- "*UzN ur fone 4 teaching*: *Strategies for teaching with mobile devices*." University of Illinois at Chicago, College of Education. September, 2013.
- "*Researching in digital spaces – strategies for human subjects protection and confidentiality in digital research today.*" University of Illinois at Chicago, College of Education. April, 2013.
- "*Collaborate with video conferencing for teaching and research*." University of Illinois at Chicago, College of Education. November, 2012.

Working Papers and Technical Reports

Riel, J. & Lawless, K. A. (2016). "Spacing count:" A metric for identifying the degree to which work is spaced out and distributed over time in distance learning and online professional development courses. Personal Working Paper: Method Report 2. http://doi.org/10.13140/RG.2.2.32359.24486/1

Riel, J. & Lawless, K. A. (2016). "Spread index:" A metric for identifying when work is completed and quantifying procrastination in self-paced, online teacher professional development courses. Personal Working Paper: Method Report 1. http://doi.org/10.13140/RG.2.1.1119.3840

Riel, J. & Lane Community College (2010). The Promise of Open Educational Resources. Technical report.

Competitive Scholarly Awards, Grants and Honors

- 2015 - University of Illinois at Chicago Graduate School Travel Grant ($150)
- 2012 - Georgetown University CCT research grant ($200)
- 2011 - HASTAC Scholar, Humanities, Arts, Science, and Technology Advanced Collaboratory
- 2010 - Ford Family Foundation Graduate Studies Scholarship ($30,000)
- 2007 - Phi Beta Kappa
- 2007 - Golden Key Society
- 2007 - Pi Sigma Alpha Society
- 2007 - James H. Dunn Fellowship, State of Illinois
- 2007 - 2nd Prize, Annual Undergraduate Technology and Social Science Conference Paper Award, National Social Science Association
- 2007 - University of Oregon Political Science Department Research Grant ($200)
- 2006 - University of Oregon Foundation Research Grant ($500)
- 2006 - Petersen Prize: U.S. Undergraduate Research Competition on the U.S. Constitution and Federalism, Willamette University Center for Law and Government ($2000)
- 2005 - Ford Scholar, The Ford Family Foundation ($40,000)

Professional Service

- AERA, annual conference proposal reviewer, 2017-present.
- SITE, annual conference proposal reviewer, 2017-present.
- UIC College of Education Technology Committee, 2016-present.
- UIC College of Education ad-hoc Facilities Design Committee, 2015-2017.
- Reviewer, gnovis Communication & Technology Research Journal, 2011-2015, www.gnovisjournal.org
- Oregon Student Association, *Member at Large - Board of Directors,* 2005-2006
- Lane Community College Student Affairs Governance Council, *Chair*, 2005-2006

Volunteer Service

- Boy Scouts of America, Oregon Trail Council, outdoors programs and digital promotions, 2003-present
- Lincoln Park Conservancy, Chicago. North Pond Gardeners & Conservationists, 2016-present.

Professional Affiliations

- American Educational Research Association (AERA), Member of Divisions C and K
- Society for Information Technology & Teacher Education (SITE)

Technical Skills

- Quantitative data analysis (including ANOVA/ANCOVA, multiple regression, logistic regression, HLM, SEM/path analysis, factor analysis, cluster analysis, and Rasch scale development) (advanced)
    - Statistical software proficiency (SPSS, R, Excel)
    - Server-generated data, learning analytics and educational data mining: data retrieval, cleanup, and programmed script implementation

- Qualitative data analysis (basic qualitative research, case study, automated coding, and behavioral/structural theme identification), data coding and rubric scoring procedures, rater agreement procedures (intermediate)
    - Qualitative analysis software proficiency (nVivo, TAMS)

- Moodle and Blackboard learning/course management systems, including online course design, implementation, course/code customization, plugins, and server interaction log analysis (advanced)

- Data and digital asset management, including data security and encryption, security protocol development, data archiving, management of data and assets across multiple web and physical locations, and new staff onboarding (advanced)
- Desktop publishing environments: Photoshop, Acrobat, Illustrator, InDesign (advanced)
- Audio production, including mixing, podcasting, studio design, and equipment (advanced)
- Photography and videography (advanced)
- Video / motion graphics desktop post-production (Premiere, Final Cut, After Effects) (advanced)
- Technical writing and technology training/tutorial documentation (advanced)
- WordPress and Drupal web content management systems (advanced)
- Programming/markup languages and environments:
    - HTML5/CSS3 (advanced)
    - PHP (intermediate)
    - MySQL (intermediate)
    - Python (basic)
    - Tensorflow / Keras AI Platform (basic)
    - Remote cloud servers: Google CP / Amazon Web Services (intermediate)
    - Neo4J / cypher graph database language (basic)
    - JavaScript / jQuery (basic)
    - Processing (derivative of Java) (intermediate)
    - Arduino (derivative of C) (basic)
- MS Windows, Mac OSX, ChromeOS, and Linux operating systems (advanced)
- Basic physical prototyping and machining, including 3D printing and subtractive CNC machinery/routing
- Intermediate electronic hardware prototyping, troubleshooting, and repair (including microcontroller integration, e.g., Arduino)