# Introduction: The Evolution of Online and Blended Teacher Learning and Professional Development

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Professional development is the chief means for improving classroom instruction and, hopefully, student achievement (Borko, Jacobs, & Koellner, 2010; Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009). Professional development comprises all of a teacher's opportunities for growth after the formal work associated with getting certified and securing a job. Although many teachers enter the teaching profession because of the high value they place on learning, too few engage in professional development on a regular, extended basis through their career. Almost all teachers participate in some professional development annually, but it is often superficial in both time and content. Whether expenditures provide a good return on investment, and how to improve the cost/benefit ratio of professional development experiences, are important educational and policy questions.

This chapter presents an overview of the role professional development and teacher learning can play in instructional improvement, given the current state of education and the present capabilities of digital media. The genesis of this book is described, as is the Summit that led to rich dialogues among its authors. An overview of the book's overall structure and its individual chapters is provided; based on this, readers can determine which parts may be most useful to them. Themes prefigured in this introduction are revisited in the final chapter, which delineates core tensions in improving the models described, an aspirational vision for the next five years, and recommended next steps for various stakeholders.

## Contrasting Professional Development with Teacher Learning

The title of this book includes the terms "professional development" and "teacher learning." The key distinctions between these are agency and formality. Professional

development may be mandated for teachers and is generally a formal experience with a fixed duration, curriculum, instructional strategy, and expected outcomes. Teacher learning, in contrast, is typically begun by an educator as a voluntary activity and may be informal, with duration, content, form of learning, and eventual impact uncertain at its inception. Given the emergence and availability of digital media, many types of both professional development and teacher learning are either online or hybrid (a mixture of online and face-to-face activities); hence, the focus of this book is on technology-mediated approaches.

The various models described in the following chapters fall on a continuum -- with mandated, formal professional development at one end and voluntary, informal teacher learning at the other – and many approaches somewhere in-between these extremes. As discussed in some of the chapters, these intermediate forms of learning may use a specific, commercial curriculum as the focus of professional development. There is an inherent tension between the goals of the developers and the users; this is often denoted as a lack of consistency between the *intended* curriculum as envisioned by the developers and the *enacted* curriculum as implemented by the teacher (Kurz, 2010).

This tension often leads to different perceived goals of professional development. For example, in communities of practice based primarily on peer learning, but enriched by experts, giving teachers what they need (e.g., strategies for promoting scientific inquiry), as opposed to what they want (e.g., a worksheet to check if students can balance equations) is sometimes a challenge. That said, the richest forms of professional learning lie towards the middle of the continuum, combining theoretical and research-based insights with the wisdom of practice. These can foster teacher ownership by providing some autonomy while accomplishing lasting

impacts via expert modeling of innovative practices and teacher-led discussions about overcoming challenges in implementation.

**The importance of professional development for educational improvement**

In discussing almost any form of innovation in schooling, the dialogue inevitably turns to how teachers can be helped to effectively adapt this new approach to the particular constraints of their own classroom settings. Despite attempts to develop "teacher-proof" instructional strategies or "teacher-in-a-box" stand-alone education technologies, enabling students to achieve deep motivation and learning requires personalized guidance from a skilled, knowledgeable educator. Many a promising instructional innovation has failed because its implementation did not include adequate methods for professional development and teacher learning.

Professional development is very important for shifts in teachers' practice because participants must not only learn new skills, but also "unlearn" almost unconscious beliefs, assumptions, and values about the nature of teaching, learning, and schooling (Dede, 2007). Professional development that requires unlearning necessitates high levels of emotional/social support in addition to mastering the intellectual/technical dimensions involved. In order for teachers of STEM education to transform from presentational/assimilative instruction to active inquiry-based forms of student learning, teachers must unlearn their own mental models, which include emotional investments developed through decades of being a student receiving traditional instruction and further years of building skills in conventional instruction. Without unlearning, teachers teach as they themselves were taught.

*The Role of Professional Development in Current Calls for Educational Transformation*

Recent research on how people learn and how to better assess students has led to new curriculum and new teaching strategies. The present landscape of teaching in the United States is dominated by the Common Core, the National Research Council Framework for K-12 Science

Education, and the Next Generation Science Standards (NGSS) (National Governors Council, 2010; Sweingruber, Keller, & Quinn, 2012; National Research Council, 2013). Although these can be viewed as political documents in that States may or may not adopt them, all States are being influenced by the changes in emphasis that these documents recommend. Teachers must be able to compare and contrast what they are presently doing in their classrooms with the vision of what could be done as articulated in these documents.

Since both Common Core (math) and NGSS (science) speak to how students will be assessed, teachers must increase their familiarity with these new assessment approaches and teaching methods, which lead to students understanding STEM knowledge and skills more deeply and increasing their ability to apply these in real-world situations. Teachers also need opportunities to discuss the limitations of the Common Core and NGSS, as some people are confounding the Common Core and NGSS assessments with limitations on the curriculum. For example, NGSS recommends that testing be limited to Newton's 2$^{nd}$ law at the high school level. Teachers can misinterpret this to mean that only one of three Newton's Laws should be included in the course. Overall, teachers need to understand that the tests are limited in scope and represent only a sampling of what students need to know, with items biased towards what can easily be measured.

Beyond these transformative shifts in STEM teaching, educational approaches must change dramatically to prepare students for work and life (as opposed to further schooling) in the modern era (Dede, 2014). Rather than moving into stable industrial jobs, young people now must compete in a rapidly shifting, global, knowledge-based, innovation-centered economy. And in order to secure a reasonably comfortable lifestyle, they now must go beyond a high school diploma, and acquire not just academic knowledge, but also character attributes such as intrinsic

motivation, persistence, and flexibility. Moreover, mastery now requires the ability to apply knowledge and skills in real-world contexts, not just in academic settings, demonstrating proficiency via effective, authentic performances.

In its landmark report, *Education for Life and Work in the 21st Century*, the National Research Council (2012) describes "deeper learning" as the instructional strategy needed to achieve these ambitious goals. The approaches recommended by advocates of deeper learning are not new, and historically these instructional strategies have been described under a variety of terms. Until now, however, they have been rarely practiced within schools:

- **Case-based learning** helps students master abstract principles and skills through the analysis of real-world situations;
- **Multiple, varied representations** of concepts provide different ways of explaining complicated things, showing how those depictions are alternative forms of the same underlying ideas;
- **Collaborative learning** enables a team to combine its knowledge and skills in making sense of a complex phenomenon;
- **Apprenticeships** involve working with a mentor who has a specific real-world role and, over time, enables mastery of their knowledge and skills;
- **Self-directed, life-wide, open-ended learning** is based on student's passions and connected to students' identities in ways that foster academic engagement, self-efficacy, and tenacity;
- **Learning for transfer** emphasizes that the measure of mastery is application in life rather than simply in the classroom;

- **Interdisciplinary studies** help students see how differing fields can complement each other, offering a richer perspective on the world than any single discipline can provide;
- **Personalized learning** ensures that students receive instruction and supports that are tailored to their needs and responsive to their interests;
- **Connected learning** encourages students to confront challenges and pursue opportunities that exist outside of their classrooms and schools; and
- **Diagnostic assessments** are embedded into learning and are formative for further learning and instruction.

These approaches to "deeper learning" entail very different teaching strategies than the familiar, lecture-based forms of instruction characteristic of industrial-era schooling, with its one-size-fits-all processing of students. Rather than requiring rote memorization and individual mastery of prescribed material, they involve in-depth, differentiated content; authentic diagnostic assessment embedded in instruction; active forms of learning, often collaborative; and learning about academic subjects linked to personal passions and infused throughout life. Active research in these desired strategies are complex, and professional development is essential as a component of this research. Teacher learning is vital for achieving the transformation in practice emerging from this shift.

## Challenges and Opportunities in Professional Development

### *Current Shortfalls in Professional Development*

A precursor to this book, Dede's edited volume, *Online Professional Development for Teachers* (2006), provides a dismal picture of professional development at that time (pp. 1-2):

> Unfortunately, at present most teacher professional development programs are not of high quality, offering "fragmented, intellectually superficial" seminars (Borko, 2004, page 3). In addition, face-to-face, pull-out programs are unable to provide ongoing daily guidance for teachers as they attempt to implement novel curricula or pedagogies. This problem of just-in-time support is exacerbated when teachers attempt to implement new strategies in environments made hostile by reluctant peers or administrators who see those innovations as undercutting the current school culture. Further, conventional approaches to professional development typically fail to provide day-to-day professional mentoring for entry-level teachers; this lack of guidance is a major factor underlying the high attrition rate among new teachers within their first five years in the classroom. As a result of all these factors, teachers often become frustrated with professional development, at times because it is ineffectual, and at times because it requires sacrifices disproportionate to the enhancement it provides.

Unfortunately, this situation has not substantially improved in the past decade. Most teacher professional development is one-size-fits-all (despite dramatic differences among individual teachers), just-in-case rather than just-in-time (so forgotten when the opportunity finally arises for application), and focused on superficial improvements rather than needed major shifts, such as transforming STEM instruction based on the Common Core Standards and the Next Generation Science Standards (Darling-Hammond et al, 2009). The easy access to technologies such as computers, tablets and smart phones and the associated growth in online communities and social networks holds promise for a shift in professional development.

The failure to provide universal, high-quality professional development in education is in sharp contrast to other professions (e.g., the law, medicine). This shortfall is in part responsible for continuing difficulties both in attracting strong people to teaching and in keeping them in classroom instruction more than a few years (Mehta, 2013). Moreover, few forms of professional development have been studied using strong methods of evaluation and research, so improvement is difficult given a lack of findings about what strategies are working well and why (Darling-Hammond et al, 2009).

*Opportunities for Improving Professional Development*

The chapters of this book delineate insights about the process of professional

development and teacher learning that have emerged in the last decade. While advances in theory and empirical research have enriched the field, the most profound change during this period has been the evolution of digital technology, particularly the rise of mobile devices, wireless broadband, and social media. A mobile infrastructure is now in place that allows educators to access professional learning experiences life-wide, regardless of place and time, using ubiquitous devices that have become part of everyone's personal activities.

Further, this infrastructure supports a broad range of peer-based capabilities for sharing educational artifacts, thinking together, and co-creating learning resources. The list below is illustrative of a much richer array of social media, digital tools on which the models in this book draw:

- **Sharing**
  - Social Bookmarking
  - Photo/Video Sharing
  - Social Networking
  - Writers' Workshops and Fanfiction
- **Thinking**
  - Blogs
  - Podcasts
  - Online Discussion Forums
  - Twitter
- **Co-Creating**
  - Wikis/Collaborative File Creation
  - Mashups/Collective Media Creation
  - Collaborative Social Change Communities

Technological constraints that plagued professional development models in 2005 are largely gone, creating exciting opportunities for rich interaction and universal access. As a result, the chapters describe models of professional development and teacher learning that go well beyond what was possible a decade ago, although to-date achieving scale and sustainability for these approaches has been difficult.

**The Genesis of this Book**

A decade has passed since the workshop at Harvard leading to the publication of *Online Professional Development for Teachers* (Dede, 2006). During that time, the publication and adoption of *Active Physics* (Eisenkraft, 2010), an innovative project-based high school curriculum, generated a need to provide high quality online professional development that received NSF support (chapter X). A related project, also supported by NSF, studied the professional development choices that teachers are making to teach the revised AP curriculum (chapter Y). That project brought Dede, Eisenkraft, Frumin, Hartley, and others together.

Based on these intersecting interests, it seemed time for another synthesis of how digital media are shaping professional development and teacher learning. Gerhard Salinger, in one of his final acts in a long, illustrious, productive and inspiring career with NSF, authorized remaining funding from one of these grants to be allocated for supporting an Online Teacher Professional Development (oTPD) Summit that was held November 14-16, 2014 at the University of Massachusetts Boston. The Summit was organized by the four co-editors of this book: Chris Dede and Kim Frumin from Harvard University and Arthur Eisenkraft and Alex Hartley from UMass Boston. Unlike Dede's previous volume, the focus of this book was narrowed to STEM teaching and learning.

After an initial planning meeting in July 2014, the organizers sent emails to people they knew, asking for recommendations for people to invite who were involved in oTPD. Approximately 100 recommendations were acquired, and 22 participants, representing a range of experiences, were selected by the organizers. Criteria for selection included published research articles and/or funded projects by NSF or similar organizations. (International participants were not selected for economic reasons.) Biographical statements of all participants are provided in Appendix 1.

Approximately half of the participants wrote a chapter before the Summit about their program and/or research. These participants were given a framework to use that listed topics to address in the chapter. Briefly, authors were asked to provide a description of the model's strategy for educational improvement, audience, balance of content and skills, primary method of teacher learning, and discussion of whether the model is a face to face, online or hybrid program. Authors were also asked to include information about the types of infrastructure and technology required by the model, the degree of commitment required of participants, how the model ensures high quality enactment, research and evaluation, the intended vs enacted models, and whether the model is intended for local professional development or the larger education community. In addition, authors were asked to speak to cross-cutting themes of scalability, cost-effectiveness, sustainability, and challenges the model has faced. All authors and the rest of the participants were asked to read 3 chapters before the Summit and come prepared to provide feedback.

The schedule for the Summit is provided in Appendix 2. Participants introduced themselves, and then sets of 2-3 papers were presented to small groups of participants who had previously read these papers. The papers were grouped by topic (Courses, Other Considerations, and On-demand Resources). After each paper presentation, participants gave warm and cool feedback using a tuning protocol. Between each round of paper sessions, participants met in jigsaw sessions that consisted of 2-3 members from each paper group, in order to share what had been discussed. At the end of the Summit, the participants who did not write chapters (dubbed "Synthesizers") reported on their summary thoughts to the whole group.

Subsequent to the Summit, chapter authors were given time to incorporate the feedback they received into their chapters and synthesizers were asked to do an analysis of the chapters

they read in reference to the themes and to create discussion questions for those chapters. The chapters in the book were then finalized through several iterations of feedback and synthesis.

**Overview of the Book**

The book is designed so that it need not be read cover-to-cover, although that is the best way to achieve an overall perspective on the current state of professional development and teacher learning for STEM education. The chapters are written to provide insights for funders, policymakers and regulators, educational leaders, developers, evaluators and researchers, teacher educators, and teachers, coaches, mentors, tutors, and informal educators. They are grouped into five sections:

1. Introductory Background
2. Models for Teacher Professional Development Courses
3. Models of Professional Development for Curriculum Support
4. Resources and Strategies for Teacher Professional Development
5. Summary Insights

Each of the sections begins with prefatory material introducing that set of chapters.

Although the model descriptions are not organized in this way, readers may wish to keep in mind the dimensions of professional development models identified in *Online Professional Development for Teachers* (Dede, 2006, page 10):

> *Sponsor:* Some models come from non-profit organizations (i.e., R&D centers, a professional organization), others from educational institutions (universities, a school district), and one from a museum.
>
> *Audience*: Some models involve individual teachers choosing to participate, others provide services to schools as organizational units, and one is internally sponsored by a school district.

*Content*: The knowledge and skills inculcated by these models include disciplinary knowledge related to curriculum, content-specific pedagogy, skills in technology use and integration, and just-in-time advice on classroom challenges.

*Pedagogy*: These models utilize combinations of pedagogies based on learning theories such as guided social constructivism, coaching, mentoring/apprenticeship, and communities of practice.

*Media:* These models span a variety of interactive media, synchronous and asynchronous, and frequently blend online and face-to-face learning.

*Assessment, Evaluation, and Research:* Depending on their maturity, these models apply a range of methodologies to understand what participants are learning, whether the program is effective, and how and why the model succeeds in what it does well.

At the end of each chapter, further questions for the reader to ponder are provided. Also at the end of each chapter, four cross-cutting themes are discussed for that model: scalability, adaptability, sustainability, and inclusivity/accessibility. Scalability refers to the extent a model can be implemented in many types of settings with varying levels of resources, not just in contexts similar to where it was first developed. Adaptability refers to how readily a model can be modified to fit local conditions without losing its effectiveness. Sustainability refers to how a model is designed to be self-sustaining over time in terms of resources. Inclusivity refers to accessibility across cultures, technical divides, diversity, physical challenges, and a host of other equity issues.

**Brief Descriptions of Each Chapter**

Immediately following this chapter and as part of the introductory section of the book, Barry Fishman (University of Michigan) considers possible futures for online teacher professional development. Often, a look forward is the last chapter in a book like this. We have decided to place it first so that readers can actively compare the models presented with Professor Fishman's forecast. His chapter explores potential answers to this question by considering: (1) shifting goals for teacher professional development, (2) the ongoing evolution of pedagogical

approaches employed in teacher professional development, and (3) shifts in technologies available to support teacher professional development. His chapter concludes with comments on the research methods commonly employed to examine outcomes related to online teacher professional development, and how a shift in these methods may lead to more scalable and sustainable designs to support teacher learning online.

*Exemplary models of courses designed for teacher professional development*

The next section of the book presents four exemplary models of courses designed for teacher professional development. One defining characteristic of courses is that individuals register for the professional development and have an incentive (course credit) to contribute in specified ways. First, Susan Doubler (TERC) and Katherine Paget (EDC) describe *Talk Science,* a professional development course that helps teachers support strategic and purposeful classroom discussions in which students build coherent lines of reasoning based on their own ideas. The professional development program is comprised of eight sessions that take place over a three-month period as participating teachers implement the *Inquiry Curriculum,* a multi-grade study of concepts and practices key to understanding the particulate model of matter. The power of video technology adopted by *Talk Science* is highlighted as a key method by which teachers see and hear alternative patterns of interchange. Four types of videos serve as the cornerstone of the web-based professional development model: Classroom Cases, Scientist Cases, and Talking Points and Strategy videos.

Second, Glenn Kleiman and Mary Ann Wolf (North Carolina State University) discuss how the MOOCs for Educators (*MOOC-Eds*) initiative has achieved impact and scale. This initiative was designed to explore whether MOOC-like approaches could be adapted to:

- Address the professional development needs of many educators—teachers, instructional coaches, and school and district administrators;
- Incorporate research-based principles of effective professional development; and
- Provide scalable, accessible, cost-effective professional development.

Their chapter summarizes what has been done and learned so far, with an emphasis on design principles and how they are incorporated into specific instructional elements within the *MOOC-Eds*.

The third chapter in this section, by Ruth Schoenbach and her colleagues at WestEd, describes a 65-hour online course, internet-based Reading Apprenticeship Improving Science Education (*iRAISE*), funded by a federal i3 (Investing in Innovation) and designed for high school science teachers. The *iRAISE course*, focused on disciplinary literacy, was based on the Reading Apprenticeship instructional framework, a pedagogical approach that has been developed over a 20-plus year history of iterative research and development with communities of practitioners. The chapter addresses the aims and questions that guided the "translation" of a 65-hour yearlong 10-day face-to-face professional development sequence into an all-online mostly-synchronous course, as well the strengths and challenges of this approach, including issues of scalability and sustainability.

The final chapter in this section, by Robert Steiner and his colleagues from the American Museum of Natural History, describes a professional development program, *Seminars on Science*, which began in 1998. The chapter then discusses the use of *Seminars on Science* within other educational programs; the development of hybrid offerings that take advantage of in-person opportunities at AMNH and elsewhere; and, finally, the development of Massive Open Online Courses (MOOCs). Enduring issues of scale and sustainability for this model are considered, as

well as the future prospects for online and blended teacher professional development at the Museum.

*Exemplary Models of Teacher Professional Development for Curriculum Support*

The initial chapter in this section, by Abigail Levy (EDC) and Arthur Eisenkraft (UMass Boston), presents the Active Physics Teacher Community (*APTC*), which was designed to help teachers who are using the *Active Physics* curriculum. This professional development model assists teachers to 1) Prepare for their classes each day by providing them with formal instruction that is directly related to the lessons they are teaching, 2) Share their knowledge, experiences, successes, and challenges with other teachers who are using the same lesson plans and curriculum, and 3) Compare the effectiveness of their teaching with the effectiveness of others' teaching, thereby allowing them to use data to inform their instruction and modify their strategies appropriately. APTC's evolutionary path is described, moving from a community designed to aid distinct groups of teachers and a particular research study to a platform serving the needs of *Active Physics* teachers nationwide.

The second chapter, by Jacqueline Miller and Katherine Paget at EDC, discusses the Electronic Teacher Guide (*eTG*), a professional development model that was developed as a proof-of-concept exemplar to determine whether a print guide for an inquiry-based, educative curriculum could be redesigned as a cybertool that would have the potential to transform and improve learning. By facilitating the implementation of the curriculum and enhancing its educative impact on teacher practice, the *eTG* is designed to help high school teachers plan, implement, and modify innovative instructional materials through providing access to rich multimedia science content and best teaching practice support. The *eTG* prototype can also provide a model for science curriculum developers and publishers for supporting teachers' "move" into the digital classroom.

The final chapter in this section, by Barbara Zahm and Ruta Demery (It's About Time), describes a cyber-learning professional development (*CyberPD*) model readily and inexpensively distributed to districts implementing Project-based Inquiry Science (*PBIS)*, an NSF-funded, middle school science curriculum. These pedagogical elements in CyberPD include driving questions, learning by design, sustained inquiry, and engaging in scientific reasoning and practices. These key elements are not separate, but are synergistic and common across all 13 units; these facilitate science learning at scale.

*Resources and Strategies for Teacher Professional Development*

The first chapter in this section, by Al Byers and Flavio Mendez (National Science Teachers Association – NSTA) presents the NSTA Learning Center, which has over 170,000 teachers spending many hours completing self-directed on-demand web modules, taking formal online courses with university partners, participating in web seminars and virtual conferences, and sharing online digital resource collections and professional insights through moderated discussion forums. This model currently has over 90,000 personally uploaded resources, over 14,000 teacher-generated public collections, and over 60,000 user generated posts on 5,800+ topics across its public and private forums. The chapter shares challenges, successes, and insights into how NSTA's platform may be configured for the local needs of individuals, as well as for entire school districts and institutions of higher education.

Next, Kim Frumin and Chris Dede (Harvard) describe the important role of moderators in online professional learning communities, as documented by research on the College Board's online Advanced Placement Teacher Communities (*APTC*) in high school biology and chemistry. Of the many forms of professional development that the College Board offers, participation in the *APTC* has the largest positive, direct, and statistically significant association

with both teacher practice and student outcomes (Fishman et al, 2014). The value of an online community lies in its ability to enable the rich and open exchange of ideas, experiences, and resources among its members. Based on theory and research, seven guidelines and other heuristics are presented by which moderators can support the changes in behavior and knowledge sharing to which an online community aspires.

The final chapter in this section, by Ray Rose (Rose & Smith Associates), describes strategies and associated resources by which providers of online and blended teacher professional development can meet their legal obligations for accessibility by people with disabilities. Standards help a program or organization develop online courses that are consistent in quality and address criteria to ensure that all relevant design issues are met. A course review process against published standards is a useful tool to help course designers create quality and accessible courses. More studies are needed on accessibility for people with disabilities in online education, including online teacher professional development, as well as on potential biases in interaction patterns online that pose threats to inclusivity.

*Summary of insights about online and blended professional development*

In the concluding section of the book, Steven Schneider and his colleagues present a chapter discussing five cases of online professional development approaches designed at WestEd. The five cases include in-depth courses, curriculum implementation wrap-arounds, hybrid, and ongoing support models. This chapter recounts the multi-threaded story of how WestEd's traditional, face-to-face delivery is evolving into a variety of online approaches, summarized in a conceptual framework that spans various types of professional development. The details of the approaches help articulate how the approaches evolved, lessons learned in its

implementation, the role of facilitators and why on-line or a blended format was considered most advantageous.

The closing chapter by Chris Dede and Arthur Eisenkraft delineates core tensions in improving the models described, an aspirational vision for the next five years, and recommended next steps for various stakeholders.

As co-editors, we've learned much from each set of authors and from their interactions at the Summit. We hope you find this book an equally rewarding experience in terms of its enthusiasm and insights. Enjoy…

**References**


Birman, B., Le Floch, K. C., Klekotka, A., Ludwig, M., Taylor, J., Walters, K., et al. (2007). *State and local implementation of the No Child Left Behind Act: Vol. 2. Teacher quality under NCLB: Interim report.* Washington, DC: U.S. Department of Education; Office of Planning, Evaluation and Policy Development; Policy and Program Studies Service.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Borko, H., Jacobs, J., & Koellner, K. (2010). Contemporary approaches to teacher professional development. In P.L. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (pp.548-556).

Darling-Hammond, L., Wei, R.C., Andree, A., Richardson, N., & Orphanos, S. (2009).Professional learning in the learning profession. Washington, DC: *National Staff Development Council*.

Dede, C., (Ed.). (2006). *Online professional development for teachers: Emerging models and methods*. Cambridge, MA, Harvard Education Press.

Dede, C. (2007). Reinventing the Role of Information and Communications Technologies in Education. In L. Smolin, K. Lawless, & N. Burbules (Eds.), *Information and Communication Technologies: Considerations of Current Practice for Teachers and Teacher Educators* [NSSE Yearbook 2007 (106:2)], pp. 11-38. Malden, MA: Blackwell Publishing.

Dede, C. (2014). *The role of technology in deeper learning*. New York, NY: Jobs for the Future. http://www.studentsatthecenter.org/topics/role-digital-technologies-deeper-learning

Eisenkraft, Arthur. *Active Physics : a project-based inquiry approach*. Armonk, NY: It's About Time, 2010.

Fishman, B., Fischer, C., Kook, J.F., Levy, A., Jia, Y., Eisenkraft, A., McCoy, A., Lawrenz, F., Dede, C., and Frumin, K. (2014). *Professional Development for the Redesigned AP Biology Exam: Teacher Participation Patterns and Student Outcomes*. 2014 AERA Paper. Philadelphia, PA.

Kurz, A. Elliott, S,N,, Wehby, J.H., Smithson, J.L. (2010). Alignment of the Intended, Planned, and Enacted Curriculum in General and Special Education and Its Relation to Student Achievement. *J Spec Educ*, *44*(3), 131-145.

Mehta, J. (2013) "Why American Education Fails—And How Lessons From Abroad Could Improve It." *Foreign Affairs, 92*:3 (May/June), 105-116

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Authors.

National Research Council. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. Washington, DC: The National Academies Press. http://www.nap.edu/catalog.php?record_id=13398

National Research Council. (2013). *Next Generation Science Standards: For States, by States*. Washington, D.C.: National Academies Press.

National Science Board (US). *Science & engineering indicators*. Vol. 1. National Science Board, 2002.

Schweingruber, H., Keller, T., and Quinn, H. (Eds). (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press.