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Abstract

This paper describes a technology-focused teacher professional development model aimed at helping teachers better acquire and integrate 21st century teaching and learning skills in their classrooms. The model is based on both a theory of teacher knowledge, **technological pedagogical content knowledge**, and the inquiry-oriented instructional method of **problem-based learning**. The model relies on problem-based learning as a method for helping teachers engage in design in order to increase both their technology knowledge and integration skills. The paper presents findings from an implementation study of the professional development model with teachers. Findings showed large gains in terms of participants' knowledge and attitudes, while web usage data also showed strong evidence of impact on participants' technology integration skills.

Objectives

Building on a decade of prior research and development, the rapidly emerging and evolving *Cyber-Infrastructure for Education* (Computing Research Association, 2005; Pea et al., 2008) increasingly provides instant access to a growing network of abundant, high-quality, free, **online resources for teaching and learning**. These resources include innovative curricula, teacher-created lesson plans, as well as interactive tools such as visualizations and simulations that support use of real-world datasets (Zia, 2001). When this infrastructure is combined with the social aspects of 'Web 2.0' functionality, the

intended result is a collaborative network not bounded by geography, time, or education context, which allows teachers and learners to **access, create, connect,** and **share knowledge** in ways that can fundamentally transform educational practice (McArthur & Zia, 2008).

Within the next decade, it is expected that access to the education cyber-infrastructure will become pervasive throughout schools in the U.S. (Computing Research Association, 2005). However, within this seemingly boundless environment, several contextual factors impact the extent to which teachers can leverage and make their own contributions to cyber-enabled learning environments. These contextual factors include:

- Due to the inherent complexity of technology integration, teachers need support in developing their capacity to teach effectively in 21st century classrooms. (Hanson & Carlson, 2005; Khan et al., 2008; Kramer, Walker, & Brill, 2007; Mardis, 2007; Recker, Dorward, Dawson, Halioris et al., 2005).

- Increasingly diverse classrooms carry a much greater need for developing tailored activities for differentiated instruction (Darling-Hammond, 2007).

- Born in a digital world, students' technology fluency is high, although critical gaps remain (e.g., Evans, 2007).

We have begun to address the gap between the skills that teachers need and these external imperatives by focusing on two, related strands of work. First, we have developed a simple, Web-based software tool that provides an important layer of functionality between teachers and the rich collections of online learning resources available to them. Launched in 2001, the **Instructional Architect** (IA.usu.edu) helps teachers quickly and easily find online learning resources and design learning activities

for their students.

Second, to support teacher usage of the IA while also supporting a broader goal of conducting research about the impact of using online resources in the classroom, we have developed a technology-focused teacher professional development (PD) model, called *DLConnect*. This model is based on both a theory of teacher knowledge, called **technological pedagogical content knowledge**, and the inquiry-oriented instructional method of **problem-based learning**. As we will describe, the model relies on problem-based learning as a method for helping teachers engage in design using online resources in order to build their technology knowledge and technology integration skills. As we will describe, we argue that problem-based learning, with its focus on use of resources to support solving authentic problem, is a particularly well-suited instructional method for this context.

The next sections of this paper describe the theoretical motivations for the model, and findings from an implementation study. In particular, the study examined impact of the PD implementation experiences on participants' technology knowledge and attitudes, as well as on their technology integration skills and (short and long term) behaviors.

The *DLConnect* Model: Theoretical Framework

Teacher professional development (PD) has long been used as a way to increase teachers' skills, and many studies have demonstrated its positive effects on instructional practices and student learning (Borko, 2004). However, while much is known about characteristics of effective PD (e.g., intensive, sustained, job-embedded, content focused, active, and collaborative), these are not precise enough to guide practice (Desimone, 2009; Wayne et al., 2008). Further, there is a dearth of studies that examine long-term

impacts of PD (Lawless & Pellegrino, 2007; Schlager et al., 2009; Wayne et al., 2008).

As described below, the *DLConnect* PD model incorporates these best practices of PD. In addition, it is based on both a theory of teacher knowledge, called **technological pedagogical content knowledge** (TPACK), and the inquiry-oriented instructional method of **problem-based learning** (PBL), described next.

Technological Pedagogical Content Knowledge

Shulman (1987) proposed that effective teachers' knowledge consisted of *pedagogical knowledge* (PK), *content knowledge* (CK), as well as their important intersection, *pedagogical content knowledge* (PCK). The latter comprises knowledge of how to effectively teach specific content areas (e.g., knowledge of common student misconceptions when learning Newton's laws).

Recent work posits additional important categories of teacher knowledge in a 21st century world, called *technological knowledge* (TK), as well as their intersections, or *technological pedagogical content knowledge* (TPACK) (Koehler & Mishra, 2005). The latter comprises knowledge about *how* to effectively teach particular content areas using technology. According to some, the technological pedagogical content knowledge (TPACK) model posits that, when combined, TPACK is greater than the sum of its parts, and that effective PD interventions integrate the three knowledge types rather than teaching them in de-contextualized ways (Schmidt, Sahin, Thompson, & Seymour, 2008).

Problem-Based Learning

Problem-based learning (PBL) is a well-established inquiry-oriented instructional method, originally developed in medical education, and now used in K-12 and university

settings (Savery, 2006). In PBL, learners acquire knowledge through engaging with authentic and challenging problems (Barrows, 1986, 1996; Savery, 2006). Typically, learners operate in small groups to solve these authentic problems using resources made available to them. The instructor acts as a facilitator, and provides scaffolds and coaching. Each problem cycle concludes with a reflection phase, in which learners discuss the efficacy of the information obtained and their solution strategies.

Overall, research shows that problem-based learning is successful in promoting student learning. Meta-analyses show PBL students performing as well on knowledge tests as their lecture-based counterparts (Gijbels, Dochy, Van den Bossche, & Segers, 2005). Moreover, when asked to perform at a deeper level, for example understanding the relationships and dependencies between concepts or applying knowledge, PBL students perform better (Walker & Leary, 2009). There is also uniform agreement across several meta-analyses that PBL students retain much more of what they learn (Barneveld & Strobel, 2009).

PBL findings specific to teachers are even more dramatic. For example, our own analysis of past work in teacher education that utilizes PBL (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006; Gulseçen & Kubat, 2006; Shoffner & Dalton, 1998) shows a weighted effect size that is extremely strong ($d = 1.14$).

In sum, the *DLConnect* model employs problem-based learning as a method for engaging teachers in design of authentic problems using online resources, in order to enhance their technology knowledge and integration skills (TPACK). In this way, our approach parallels the *learning technology by design* model proposed by Koehler & Mishra (2005), but uses problem based learning as the focus rather than as an element of

the intervention. This is not only because of the positive findings reported above, but because PBL is particularly effective (Walker & Leary, 2009) when learners are engaged in design problems (Jonassen, 2000).

The next section describes the technology context for our work, followed by a description of and findings from an implementation study.

The *DLConnect* Model: Technology Context

The context for the professional development is learning to use a web-based tool **the Instructional Architect (IA)**, to author instructional activities for students using online learning resources. Teachers can use the IA in several ways. Once logged in, the **'My Resources'** area of the IA allows teachers to directly search for and save online learning resources from the Web, including interactive and Web 2.0 content (such as RSS feeds and podcasts), and add it to their list of saved resources. In the **'My Projects'** area, teachers can design web pages (called IA projects) in which they select a look and feel for their project, input selected online resources and provide accompanying text. Finally, teachers can **'Publish'** their IA projects for only their students, or the wider web world.

The *DLConnect* Model: An Implementation

The *DLConnect* professional development model is implemented as workshops, conducted as face-to-face or online sessions over two months, with in-between teacher and classroom activities. Incorporating important, research-based characteristics (Desimone, 2009; Wayne et al., 2008), it is sustained, centered on authentic problems, content focused, active, and collaborative.

Table 1. *DLConnect* PD model (P=pedagogy; C=content; T=technology; TPC=Technological pedagogical content knowledge; PBL=problem-based learning)

Phase	PD Activities	Theory	Data
Workshop 1	Divide participants into small groups Demonstrate use of the IA	PBL T	Pre-survey

	Initiate discussion about PBL through review of PBL instructional activities	P	
	Participants select relevant design problem	C	
	Introduce online resources and IA to address design need	TPC	
	Groups begin to design IA project(s) to address need	PBL	
	As needs surface, show further use of IA and online resources	TPC	
	Review critical elements of PBL	PBL	
In-between activities	Participants design and implement IA project(s) in classroom	TPC, PBL	
	Participants review peers' designed activities	TP	
	Participants revise based on peer feedback	PBL	
	Participants write reflection paper noting barriers and successes	PBL	Reflection papers
Workshop 2	Small group discussion of implementation experiences	TPC	Post-survey Web usage data
	Whole group discussion on successes and failures	TPC	
	Participants revisit instructional problem	PBL	
	Review use of the IA and online resources	T, PBL T	

Table 1 shows an outline of workshop activities, important TPACK and PBL theoretical influences, and research data collection points. The hallmark of the model is the use of authentic design problems. Early in the workshop, participants are asked to select an authentic instructional problem or need in their classroom (e.g., a new curricular unit, a topic with high student misconceptions, etc). Then using a problem-based learning approach, they find suitable online resources to support problem solution, and design instructional activities for their students using the Instructional Architect.

Following the model of TPACK, recommended **technology skills** are introduced at the point of need so that participants understand how and why the technology supports their activities (Knowles, Holton, & Swanson, 1998). Technology specific portions of the curriculum include components of basic information literacy skills training, (e.g., search techniques, and critical thinking exercises about online content quality) and highlight the mechanics of using the IA to ensure that participants are able to find, share, and

effectively use online learning resources in support of their design problem.

The next sections describe the methods for and findings from a face-to-face implementation of the professional development model. In particular, we were interested in gauging the impact of the workshops on participants' technology knowledge and attitudes, and (short and long term) behaviors with regards to their use of and design with the IA.

Methods and Data Sources

Participants

The implementation study involved 23 participants, who were classroom teachers drawn from the same rural school district. Complete data was collected from 20 participants.

Design and Procedures

The research design consisted of mixed methods, in a one-group pre-test, post-test design (Campbell & Stanley, 1963). The procedures used and data collected are summarized in Table 1 above. Analyses involved a mixed method approach (Johnson & Onwuegbuzie, 2005), drawing from analyses of pre- and post-workshop online surveys (consisting of both open-ended and Likert scale items), reflection papers, and web usage data automatically collected by the IA during participants' online activities (called *webmetrics* (Khoo et al., 2008)).

Findings

Knowledge and Attitudes. Effect sizes show large increases between pre and post survey responses in terms of participants' experience with creating online lessons, their knowledge using technology in the classroom, and their confidence in teaching with

technology (see Table 2). Due to the small sample size, pre-post differences are reported

in terms of an effect size comparison, Cohen's *d* (1988), with the pooled estimate of the

population standard deviation as the denominator. Cohen characterized effect sizes of .2

as small, .5 as moderate, and .8 and higher as large.

Table 2. Participant Self Report on Technology Integration

	pre-survey		post survey		
Self report (scale from 0=low to 4=high)	**M**	**SD**	**M**	**SD**	***d***[1]
Experience creating online lessons	1.64	1.40	2.89	0.94	1.07
Knowledge using technology in the classroom	1.88	1.05	2.84	0.96	0.98
Confidence in teaching with technology	1.92	1.08	2.95	0.78	1.12

Behaviors. *Webmetrics* analyses show a large number of logins to the IA, created IA

projects, and resources used. These can be seen as an indication of successful workshop

impact on participants' technology integration skills (see Table 3). The mean number of

times each IA project was accessed (visits) is also large ($M = 71.36$), indicating high

student usage of the IA projects and their associated online learning resources. Finally, as

a glimpse of long-term behavioral impact, five (25%) participants were still active IA

users 8 months later. Since PD studies seldom report long-term impact data (Wayne et

al., 2008), it is hard to know how this implementation of *DLConnect* compares.

Table 3. *Webmetrics* (Usage) Analyses

	M	**SD**	**Mi n**	**Max**
Number of logins	26.72	21.53	4	92
Number of IA projects created	6.68	4.88	2	17
Number of online resources used	27.52	27.82	1	105
Number of visits to IA project (N > 0)	71.36	117.99	1	888

Reflection papers paralleled and provide deeper explanations of the survey data. One

high school English teacher was able to see greater possibilities for the technology,

writing "I have intentions to use it in the future as well. I have written a grant in which

[I] mentioned [Instructional Architect] as a great tool for spreading learning from teacher

to teacher." A Language Arts teacher reflected that she was able to take her students

knowledge to a greater depth of knowledge about the Illiad with her new skills:

> "I collected information about the background, key players, and themes
> found in The Illiad that allowed the students to become more informed on
> the subject. Instead of letting them browse whatever site they chose, we
> took each site together and discussed the things that were presented."

Significance

In sum, participants showed dramatic gains in terms of their knowledge and attitudes

as a result of participating in the professional development. Web usage data showed clear

usage of IA projects, both short and long term, strong evidence of impact on participants'

technology integration skills. Future work will focus on aligning the workshop model

more closely with problem-based learning. It will also focus on studies better designed to

untangle causal effects of PD features and teacher and student knowledge, attitudes, and

behaviors.

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