2012

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Abstract

Using a comparative case study design, this paper explores the impacts of two technology-related professional development (TTPD) designs, aimed at helping teachers design classroom activities using the wealth of resources available on the Internet. The case study is part of a larger mixed-method study involving 36 teachers and over 1,200 students. Using the lens of curricular adaption, we analyzed the experiences of two teachers from each of the two TTPD designs in terms of the kinds of instructional activities teachers designed, how these were supported with online resources, and teachers' perceptions of impact on student learning. Findings suggested that participants used a variety of personally relevant design strategies when applying TTPD concepts to their contexts. In particular, the teachers discussed how they tailored instruction to fit student needs and their interests, and how they incorporated instructional games, simulations, and interactive resources to enhance motivation and provide self-paced instruction. Finding also helped clarify results from the quantitative study by highlighting differences between the designed artifacts and subsequent classroom implementations.

Keywords: technology-related teacher professional development, comparative case study, problem based learning

Introduction

The past decade has seen enormous growth in the Internet-based network of free, online resources available for teaching and learning. These resources, variously called learning objects, open educational resources, or online learning resources, include innovative and interactive curricula, teacher-created lesson plans, as well as tools such as visualizations and simulations that support the manipulation of real-world phenomena and datasets (Borgman et al., 2008; McArthur & Zia, 2009; Zia, 2001). These resources are often aggregated, curated, and made available in content-rich resource collections (e.g., The Digital Library for Earth System Education), and portals that facilitate educator access such as *the National Science Digital Library, Teachers' Domain*, and the recently-announced U.S. Department of Education *Learning Registry.* The vision is that, supported by this increasingly available infrastructure, teachers and students can access, create, connect, and share knowledge in ways that fundamentally transform practice (Borgman et al., 2008).

Yet little is known about what kind of instructional practices best support student learning with online resources (Borgman et al., 2008; Mervis, 2009). Moreover, despite educators' documented beliefs that online resources can enrich their classrooms and improve student learning (Recker et al., 2006), many barriers remain. These include inadequate technology access, insufficient technology knowledge, and the overall inherent complexity of classroom technology integration Hanson & Carlson, 2005; Kramer, Walker, & Brill, 2007; Mardis, 2007; Recker et al., 2005).

Studies have documented that teacher professional development can be an effective way to improve teacher knowledge (e.g., Borko, 2004). As such, to help teachers develop technology integration knowledge and skills, we developed two technology-related teacher professional development (TTPD) designs. Both focused on helping teachers learn to design activities for students using online learning resources. In the first design, the TTPD design focused on helping teachers integrate new technology skills with a self-chosen pedagogy. The second design paired learning technology skills with an inquiry pedagogy, specifically problem-based learning (PBL; Barrows 1986). The impacts of each TTPD design were evaluated and compared in a quantitative study involving 36 teachers and over 1,200 students (Walker et al., 2012). Results from this work are described in more detail below.

While the results of the quantitative study revealed significant proximal and self-reported impacts, less was known about the experience of individual teachers when attempting to apply TTPD concepts in designing and implementing classroom activities using online resources. As such, against the background of the quantitative results, the purpose of this article is to present findings from a comparative, multiple case study. In particular, the experiences and activities of two teachers from each of the two TTPD designs were selected for in-depth analysis. Using the lens of curricular adaption, we examined the kinds of instructional activities teachers designed, the pedagogical strategies they used, how these were supported with online resources, and teachers' perceptions of their impact on student learning. We also examined the barriers teachers encounter during design and implementation. Finally, we examined how case study findings clarified and expanded results from the quantitative study.

In the next section, we describe the theoretical framework underlying our study. We then describe the study context, as well as briefly review the results from the quantitative study. We then present findings from the case studies, and conclude with a discussion of implications and limitations.

Theoretical Framework

While less is known about teacher use of online learning resources, prior research has examined teacher adoption (and non-adoption) of curricular material (Ball & Cohen, 1996; Remillard, 2005). This work has critically examined the assumption that curriculum materials are implemented unchanged by teachers. In a review of the literature, Remillard (2005) proposed a framework for describing teacher use of curriculum, in which teachers' beliefs, knowledge, and identity interact with curriculum features (e.g., representations, structures, voice). This participatory relationship influences resulting design and enactment. This perspective fits with a more contemporary view of teaching as a kind of design task, in which teacher adaptation and use of materials is seen as a critical step in curriculum design.

In empirical work, studies have found that teachers do adapt curriculum to fit their teaching context (Squire, MaKinster, Barnett, Luehmann, & Barab, 2003). This adaptation process can support both the development of instruction tailored for individual students, as well as help the teacher learn new content and skills (Davis & Krajcik, 2005).

Another study suggested that teachers vary with respect to their ability and skills to engage in principled adaptation of curriculum in order to design instructional activities for their students, as skill dubbed *pedagogical design capacity* (Brown & Edelson, 2003). In this view, curricular materials afford and constrain design, interacting with teachers' unique knowledge, skills, and experience. As part of this research, Brown and Edelson defined a continuum of teachers' curriculum use, which ranged from *offloads* to *adaptations* to *improvisations*. This continuum describes the degree to which the design of instructional activity is differentially divided between the instructional resources and the teacher. They also noted that the continuum is neutral with regards to quality or effectiveness of the resulting designed activity. In an *offload*, the curriculum resource is implemented essentially unchanged, and the majority of instructional decisions are scripted within the resource. At the other extreme, *improvisation*, a teacher may flexibly mix and match aspects of the curriculum while playing a large role in instructional decision-making. Adaptation, then, represents the mid-point on the continuum.

Supporting this view, some scholars argue that teacher professional development should explicitly focus on supporting teachers in productively designing with such materials (Brown & Edelson, 2003; Davis & Varma, 2008; Lawless & Pellegrino, 2007). In this way, teachers increase their pedagogical design capacity in order to make principled adaptations of high quality curriculum materials that are responsive to the needs and interests of their students, as well as to local standards (Penuel & Gallagher, 2009).

In this work, we do not mean to imply that curriculum usage and adaptation necessarily entails the same processes as using online resources. For example, we do not imply that online resources play the same role as, for example, a district-mandated curriculum. In the latter, organizational factors clearly play a large role. Instead, we use this lens to consider how teachers choose to use online learning resources in their own design and implementation of classroom activities.

Finally, we note that Brown and Edelson were examining instructional planning and classroom implementation together. We separated these temporal events by examining the activities designed by teachers as well as the reports of classroom implementation experiences, stopping short of observing classroom implementation. Others have also proposed this differentiation between planning and implementation (e.g., Drake & Sherin, 2006; Remillard 2005).

In the remaining sections, we use Brown and Edelson's (2003) notion of *pedagogical* *design capacity* and continuum of teachers' curriculum use to examine four teachers' design and implementation experiences.

Case Study Context

This case study is part of a larger, mixed-method study of TTPD impact. The study took place within a large, suburban school district (75,000 students) in the western U.S. Thirty-six junior high school mathematics and science teachers and 1,247 students participated in the quantitative study. The quantitative portion was primary, due to the nature of the research questions, and analyzed first (Johnson & Onwuegbuzie, 2004). In the quantitative portion, the impact of two TTPD designs was compared in a quasi-experimental study. Both TTPD designs focused on enhancing participating teachers' technology skills for finding and selecting online resources from the wealth available on the Web, and designing classroom activities around these resources using web-based software called the Instructional Architect (described next). In the qualitative portion, a comparative, multiple case study (Yin, 2009) was conducted to clarify and expand understanding of teachers' implementation experiences, as well as results from the quantitative portion. In this section, we describe the technology context (the Instructional Architect), and the two TTPD designs.

Technology Context

The technological context for the TTPD is a free, web-based tool, called *the Instructional Architect (IA.usu.edu)*. It supports teachers in authoring instructional activities for students using online resources increasingly available on the Web and in specialized educational repositories such as the National Science Digital Library (*nsdl.org)*.

Teachers can use the IA in several ways. Once logged in, the *'My Resources'* area allows teachers to search for and save links to online resources, including interactive and multimedia resources. In the *'My Projects'* area, teachers can select online resources and annotate them with text to create learning activities (called IA projects). Finally, teachers can *'Publish'* these IA projects for their own students, or anyone on the Web. In addition, the IA allows for teachers to collaborate, by sharing with and copying IA projects from other IA users.

Since 2005, the IA has over 6,100 registered users who have gathered over 70,000 online resources and created over 13,600 IA projects. Since August 2006, public projects have been viewed over 1.5 million times. Examples of IA projects created by each of the case study participants are presented below.

Professional Development Designs

In the full study, two TTPD designs were contrasted. Both TTPD designs focused on the following technology skills: 1) finding online resources, 2) designing activities for students using the IA, and 3) implementing these IA projects in the classroom. The two TTPD designs were implemented as a series of three workshops with in-between activities, conducted face-to-face over three months. Following design-oriented approaches in technology-related professional development (Lawless & Pellegrino, 2007), the participants engaged with authentic and complex problems in their own teaching, designed solutions using the IA, implemented these in their classrooms, and reflected with their peers on classroom implementation.

The two TTPD designs differed in that the first design (*tech-only*) focused exclusively on enhancing technology knowledge and skills. In particular, the additional focuses were on search strategies for online resources, methods for evaluating their quality, as well advanced IA skills to design instructional activities coupled with the pedagogy of their choice. The second TTPD design (*tech+pbl*) coupled technology knowledge and skills with learning to design inquiry-oriented activities, specifically problem-based learning (PBL), for their students using the IA.

Phase	*Tech-only* TTPD	*Tech+pbl* TTPD	Data Collected
Workshop 1. 3 hours	1. Take pre-survey 2. View example IA projects 3. Select a teaching goal 4. Intro to online resources 5. Intro to the IA 6. Discuss selection of quality online resources 7. Individuals design IA project(s) 8. Review IA functionality	1. Take pre-survey 2. View example PBL IA projects 3. Select a teaching need 4. Intro to online resources 5. Intro to the IA 6. Individuals design IA projects 7. Large and small-group discussion on inquiry learning and designing inquiry problems	• **Pre-survey**
Classroom implementation 1	1. Design and implement IA project(s) with students 2. Administer student questionnaire 3. Write reflection paper on barriers and successes in classroom implementation	1. Design and implement IA project(s) with students 2. Administer student questionnaire 3. Write reflection on barriers and successes in implementation. 4. Devise potential inquiry problems suitable to context	• Student pre/post questionnaire • **IA project 1** • **Web usage data** • **Reflection paper 1**
Workshop 2. 3 hours	1. Small then large group discussion of implementation experiences 2. Review use of the IA, including advanced tech features 3. Small group discussion on existing and potential new IA projects 4. Design a new IA learning activity 5. Large group discussion on the IA and project design	1. Small then large group discussion of implementation experiences 2. Review use of the IA 3. Engage in inquiry-oriented activity 4. Large group discussion of inquiry and PBL 5. Design own PBL learning activity 6. Share ideas in small then large groups	
Classroom implementation 2	1. Design and implement new IA project(s) with students 2. Administer student questionnaire 3. Write reflection paper on barriers and successes in classroom implementation	1. Design and implement new IA project(s) with students, encouraging use of PBL. 2. Administer student questionnaire 3. Write reflection paper on barriers and successes	• Student pre/post questionnaire • **IA Project 2** • **Web usage data** • **Reflection paper 2**
Workshop 3. 3 hours	1. Small then large group discussion of implementation experiences 2. Review technical use of the IA, including advanced features 3. Take post survey	1. Individual reflection on IA project and PBL implementation 2. Small then large group discussion of IA project and PBL implementation 3. Review technical use of the IA 4. Take post survey	• **Post survey**
Two months later			**45-minute interview**

Figure 1. Key activities for the two TTPD designs and data collection points (bolded items represent data used in the case study).

Figure 1 shows key activities for the two TTPD designs, as well as all data collection points and data sources. Table 1 summarizes the data sources used in the case study (bolded items in Figure 1).

Table 1

Data Source Details

Data Source	Description	Type
Pre/post survey	Participants completed pre/post online surveys, consisting of 18 Likert-scale items and 2 open-ended items addressing teacher knowledge and skills.	Quantitative and Qualitative
IA project content	Participants designed and implemented two IA projects, one each after Workshop 1 and Workshop 2. These were examined to determine what pedagogy was used and how it was supported with online resources.	Qualitative
Web usage data	Automatically collected data of participants' use of the IA, including number of logins, IA projects created, collected resources used, and project visits.	Quantitative
Reflection papers	Participants responded to 6 prompts: 1. Describe how you designed this lesson to be taught and used. 2. Describe successes and difficulties in implementing the activity with your students. 3. How did the use of the Instructional Architect change the way in which you taught this material compared to how you've taught it in the past? 4. Describe how you could use the learning resources you found to use in Instructional Architect projects in your classroom in the future. 5. How did you find learning resources to use in your IA project? 6. The goal of this workshop is to empower teachers with the skills and tools necessary to effectively integrate technology into their teaching practice. In your opinion, how effective is the workshop at accomplishing this goal?	Qualitative
Semi-structured Interview (45 minutes)	Participants responded to these general prompts: 1. How did using the IA and online resources influence your instructional methods? 2. Describe how you used these IA projects in your class - for example - did you have the students in small groups, whole class, individually? 3. What you think your students learned from this activity. Do you think what they learned would have been different if they had done it without using technology?	Qualitative

Results From Quantitative Study

Table 2 shows the research questions guiding the quantitative portion of the study, and a brief description of key results. In sum, results showed that teachers' in both groups showed significant gains in their technology and pedagogical knowledge, as well as high usage of the tools. Teachers who learned the PBL pedagogy showed significant gains in their use of PBL, and their students also showed significant gains in self-reports of knowledge, attitudes, and behaviors, whereas students of teachers in the other group only showed in significant gains in attitudes (Walker et al., 2012).

Table 2

Quantitative Research Questions, Data Sources, and Key Results

Research Question	Data Sources	Key Results
1. What is the impact of the two TTPD on teachers' knowledge?	Teacher pre/post surveys	• Teachers from both TTPD groups significantly improved their pedagogical and technological. • Teachers in the *tech+pbl* group gained significantly more PBL knowledge
2. What is the impact of the two TTPD on participants' usage of the IA?	IA usage data	• Teacher usage is high for both TTPD designs, with high numbers in teacher logins, online resources used, and IA projects created. • Student usage also appears high for both TTPD designs in visiting the IA projects created by their teachers.
3. What is the impact of the two TTPD on teachers' use of PBL in IA projects?	IA projects were coded using a rubric for presence of PBL elements	• *Tech+pbl* teachers' use of PBL elements increased significantly in their second IA project design
4. What combination of teacher and student variables significantly predicts student knowledge, attitudes and behaviors?	Student pre/post questionnaires of knowledge, attitudes, and behaviors	• *Tech+pbl* students showed significant increases in gain scores for all three outcomes after the second classroom implementation. • *Tech-only* students showed significant increases in gain scores only in attitudes after the second classroom implementation.

Case Study Research Design And Methods

The qualitative portion of the study was comprised of a comparative, multiple case study (Yin, 2009). Cases were bounded by a classroom with an associated teacher, students, and the IA projects used. The research questions investigated were:

- How do participants describe their experiences when designing and implementing TTPD concepts and skills in their classroom activities? What kinds of activities did they design, what pedagogical strategies were used, how were these supported with online resources, and what were teachers' perceptions of impact on student learning? What barriers did teachers encounter during design and implementation?
- How do case study findings clarify and expand results from the quantitative study?

Participants. Two participants were purposively selected from each of the TTPD conditions, *tech-only* and *tech+pbl*. For each TTPD condition, using teacher self-reported pre-survey data, one high technology knowledge teacher and one low technology teacher were selected in order to represent the full range of existing technology skills among participants (see Table 3). All participants were experienced junior high school teachers, having taught more than three years. Three were science teachers, and one (Mr. O.) was a math teacher.

Table 3

Participants in the Case Study

	tech+pbl	*tech-only*
High Tech Knowledge	Mrs. R.	Mr. W.
Low Tech Knowledge	Mr. O.	Mrs. B.

Data Sources and Analyses. Figure 1 shows in bold the data sources that were primary for the case study, as well as when the data were collected during the study. Teacher survey data were used to compute percentage gains from pre to post. The contents of each teacher's IA projects, designed and implemented after the first and second workshops, were examined for their overall design and presence of PBL elements. Web usage data was collected to determine teacher and student use of the IA.

Reflection papers provided by each of the participants were collected after the second and third workshops. In these papers, teachers were asked to respond to prompts shown in Table 1.

The four teachers were interviewed by one of the authors approximately two months after their participation in the TTPD. Each interview was approximately 45 minutes long, and was framed by a set of open-ended questions that enabled teachers to discuss their experiences (see Table 1). The interviews were recorded and transcribed.

The interviews and reflection papers were analyzed using the constant comparative method (Miles & Huberman, 1984). Case narratives for each of the participants were constructed, repeatedly read and segmented (coded) for data reduction and identification of themes, and triangulated with the quantitative data to search for consistent themes as they addressed the research questions.

Case Study Findings

Table 4 presents a summary of the participants.

Table 4

Case Study Participant Characteristics

Name	TTPD group; Tech knowledge	IA Project Topic #1	IA Project Topic #2	% gain survey	# logins to IA	# online resources used	# IA projects created
Mrs. R.	*Tech+pbl;* High	Solids, liquids, and gases	Density	43%	50	21	6
Mr. O.	*Tech+pbl;* Low	Interpreting graphs and tables	Scientific notation	15%	37	15	5
Mr. W.	Tech-only; High	Ecology	Physical and chemical change	7%	37	42	11
Mrs. B.	*Tech-only;* Low	Classification	States of matter	39%	39	63	13

*Usage data collected 6 months post-TTPD

As shown in Table 4, all participants showed generally high usage of the IA, with Mrs. B. creating the most IA projects and collecting the most resources. Mrs. R. logged in the most to the IA, but designed the smallest number of IA projects. In terms of teacher self-reported pre/post survey scores, all four teachers showed gains. Mrs. R. had the most gains, with Mr. W. the lowest. Mr. O., who had the lowest gains in technology knowledge, was the least active IA user.

Research Question 1: Impact on Teachers' Design and Implementation Experiences

Case 1, Mrs. R.: high technology knowledge in *tech+pbl* group. Mrs. R. is a junior high school science teacher. Her first IA project was on the topic of "solids, liquids, and gases", while her second taught the concept of density. Her second IA project showed many aspects of PBL, including the use of an open-ended and authentic problem, links to resources to help in finding the solution, and reflection prompts. In this project, students are presented with a real-life problem ("building a raft to cross a lake"), and provided links to resources to help them understand density (see Figure 2). One resource was a game that allows the user to manipulate block properties in order to visualize how it floats. In this way, the IA project shows an *improvisation* in the way it uses online resources to support her PBL task.

The following quote illustrates how Mrs. R. thought about how to implement problem-based learning elements within her IA project:

> "It got them thinking about how density is a part of true life. I liked that. I liked that they were thinking about something other than being in a classroom playing with the toys in front of them. They could figure out exactly real life concepts." [Interview]

These examples show how Mrs. R. attempted to make connections to a real-life problem, while allowing students to engage in discovery. Mrs. R. also noted the motivating power of online educational games and simulations, and how these can help students learn better, especially challenging concepts:

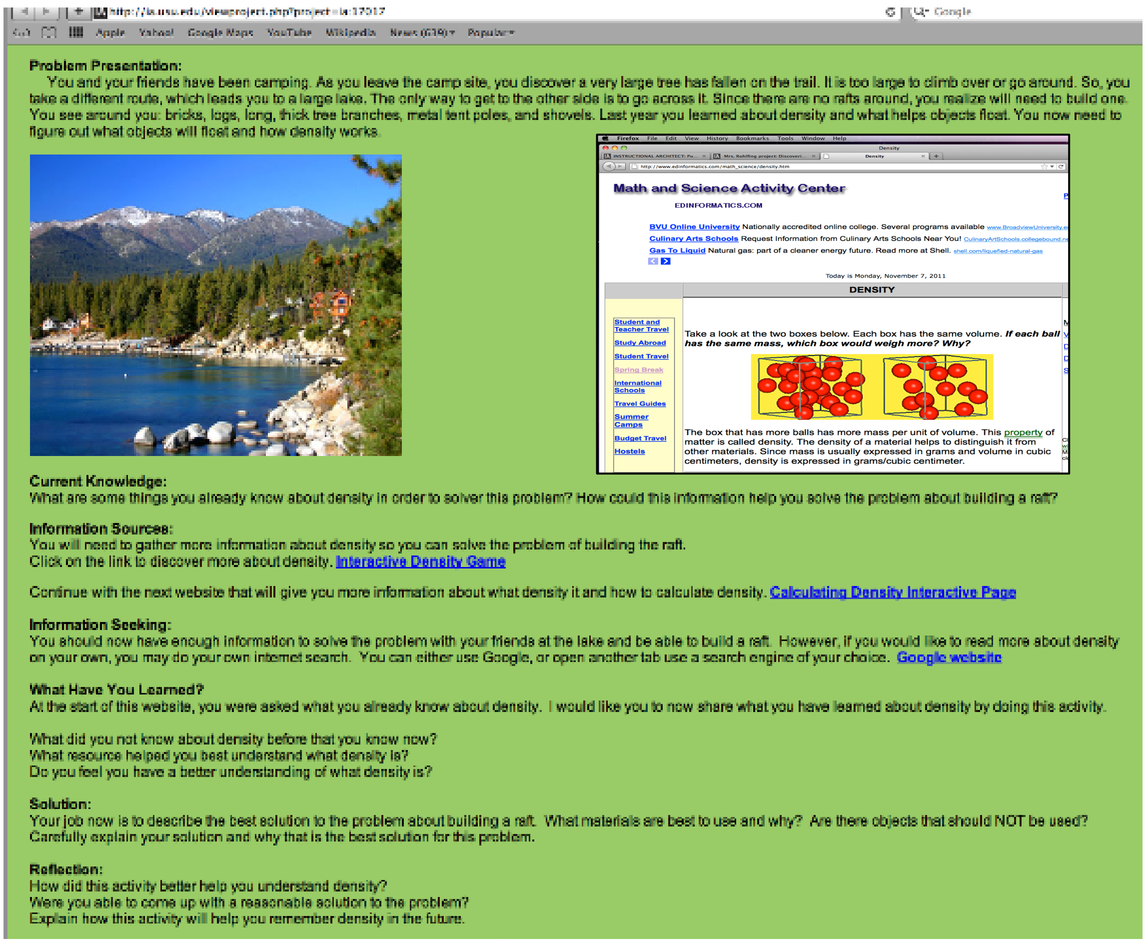

Figure 2. Screenshot of Mrs. R.'s second IA project.

"Density is so hard to teach and to show them and to have those visual little games that were included on the project. They were just playing them the whole time. I told them to move on. So I think they liked the idea of playing around and trying to figure out a concept rather than me telling them this is what it is and why you do it." [Interview]

"There were a few games they could play on Discovering Density so most of them were so into playing the games. They had to be reminded to actually move on." [Interview]

"But I think they [the students], being able to play around is a whole lot more fun than doing calculations on the calculator. This is more visual than crunching numbers, so I think they enjoyed this more." [Interview]

"Would it have been different if they had not used technology? Yeah, I've never introduced density in this way before. I've never used technology to introduce density, which is why I chose density, it's a difficult concept for 7th graders to learn." [Interview]

Thus, Mrs. R. noted the dual advantage of motivation and better learning. Mrs. R. also commented on how using the IA changed her instructional approach, and helped her feel more organized. She also noted her plans to re-use the project to help students prepare for end-of-level testing:

"I think it added variety to my instructional methods because I've never seen anything like this before. I always thought it would be nice to create my own websites, that students could get the information that I wanted them to get without them doing search." [Interview]

"It [the IA project] was better outlined [than] I may have done in the past and it provided students with more information that I would have provided in one class period. I felt I was more organized and I also feel that students got all the required information." [Interview]

"I will keep this website that I created because students had a lot of fun with it. I can also use it as a review at the end of the year again right before we take the end of level tests." [Reflection 2]

Additionally, Mrs. R. noted several technical barriers to fully implementing her IA projects. These related to poor network bandwidth and access to computer labs:

> "The only problem I had with it, or negative part was the system, was that the computers took awhile to load some of the games, so they kind of got frustrated." [Interview]

> "The first one for solids, liquids and gasses, I was not able to schedule the computer lab, there were too many full schedules already." [Interview]

Finally, Mrs. R. noted that she shared this project with another teacher, something harder to do with paper lesson plans. This perhaps also accounted for high number of student visits:

> "I shared this website with another teacher in my building and she used it for her students as well. She used it for more of a review, but said that her students had fun with it as well." [Reflection paper 2]

Case 2, Mr. O.: low technology knowledge in *tech+pbl* group. Mr. O. is a junior high school mathematics teacher. His first IA project was on the topic of "Interpreting graphs and tables", while his second covered scientific notation (see Figure 3). Mr. O. was a lukewarm IA user, recording some of the lowest number of logins to the IA, as well as number of resources collected and IA projects created. Finally, the TTPD seemed to have a modest impact in that he only reported modest gains in the survey (see Table 4).

Mr. O's second IA project on scientific notation was very short, with only a small amount of text and a few links to resources containing examples (see Figure 3). However, as he explained in his interview, he wanted students to deduce rules (a more inquiry approach) by looking at examples:

> "That's not a true discovery lesson that I came up with but it was closer than I did the first time. Because they were looking at examples, correct and incorrect ways in writing scientific notation and they were trying to come up with the rules on their own. So they were doing deductive thinking rather than just being told the rules." [Interview]

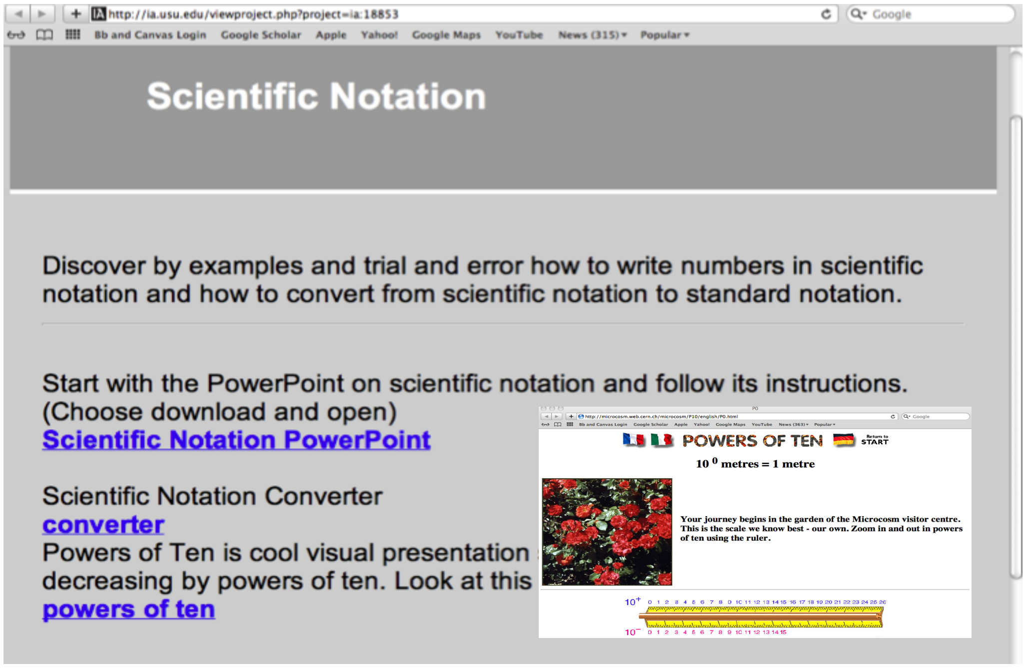

Figure 3. Screenshot of Mr. O.'s second IA project.

In this way, while the IA project can be characterized as an *offload,* with very little evidence of teacher design, his interview suggests that the classroom implementation used more of an *improvisation* approach in that the resources were a catalyst for inductive thinking.

Mr. O. noted that the technology was good at giving immediate feedback to his students, and that his students general were proficient enough to access his the IA project:

> "The kids were good at using the technology, you know -following the powerpoint, and those kind of things they knew. They were fairly technical – had the technical savvy to follow the lesson." [Interview]

Finally, Mr. O. noted the key barrier to implementation for him was having enough time to fully develop his lesson, as well as having unfettered access to the school computer lab:

> "You know, when we're in the lab we're limited by the time and we can't, you know, follow up the next day because we don't have the lab scheduled. Time was the biggest

issue. Even the classroom time made it hard to really develop the lesson the way I wanted to, you know with the technology." [Interview]

Case 3, Mr. W.: high technology knowledge in *tech-only* group. Mr. W. is a junior high school science teacher. His first IA project addressed the topic of ecology while his second was on physical and chemical changes. Mr. W. had a low number of logins to the IA yet collected a large number of resources (see Table 4). On the survey, Mr. W. recorded the lowest percentage gains from pre to post.

Mr. W.'s second IA project displayed no evidence of using PBL, and can be characterized as an offload, in that it consisted of instructions of what to do with various links. Unlike the other teachers, some of these links were to resources Mr. W. had previously created, including an assignment. Students were asked to complete the assignment and upload it to a district site. The other online resources were links to examples demonstrating the chemical processes as well as to an online quiz (see Figure 4).

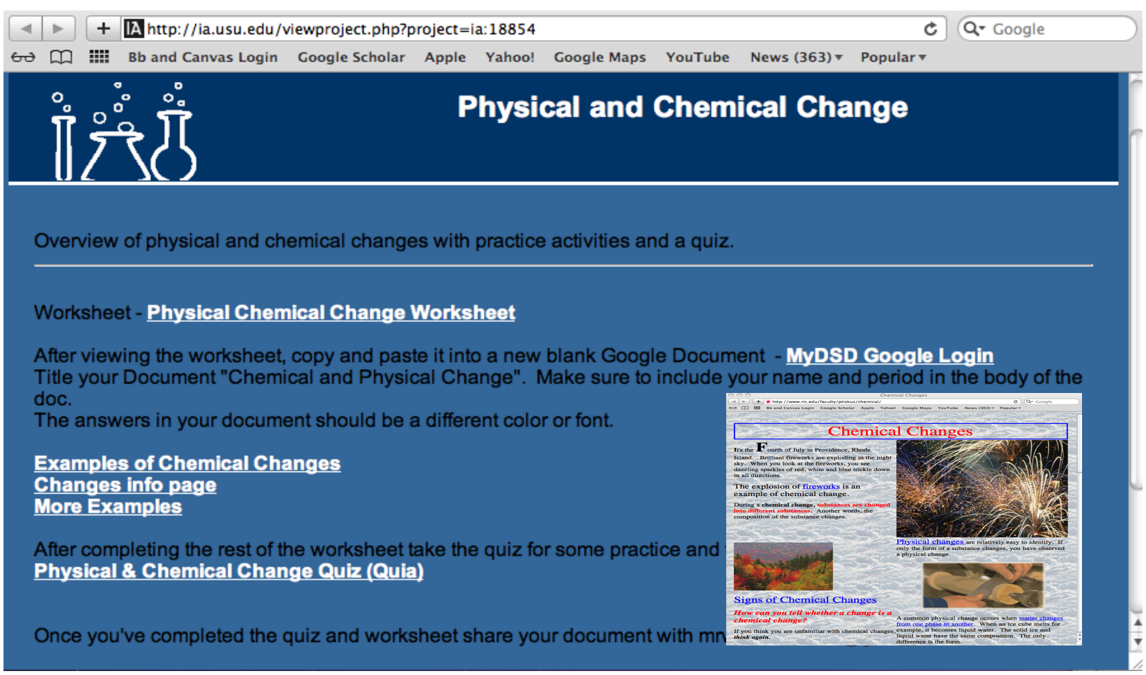

Figure 4. Screenshot of Mr. W.'s second IA project.

Mr. W. noted the power of interactive visualizations in his first IA project that had a link that provided some hands-on experiences:

> "So this one is much more involved and interactive, I think they learned how, organisms, just attributes and helps survive in the environment, they saw it visually, and they could move their picture around certain things with it, so, I think it was more of a … I think it was a lot better for them to take those traits and apply it. So adding technology was more as far as creating their creature. I think it was interactive." [Interview]

Mr. W also commented on his students' ability to learn to use the IA and online learning resources:

> "They learned just as good as, probably a little bit better than how they did in the past. This is how I think we should change, yeah, I think they learned stuff they normally wouldn't." [Interview]

In addition, Mr. W commented on how focused his students were while using the IA:

> "You put them in this setting (IA), and they are focused. I think it helps it be accessible to more students, just because they could learn in different ways." [Interview]

> "The students stayed well on task; they liked using the computers." [Reflection paper 2]

Mr. W also noted that this approach allowed content to be covered more quickly as well as enable students to work in a self-paced manner, thus freeing up the instructor to work one-on-one with his students:

> "I wouldn't be able to get through that many class and they (students) were just able to look and then access. (It) made them quicker. So I covered more material that time than I would normally could in class." [Interview]

> "(I conducted) the informal assessment in the classroom with them, because I'm not directly instructing them, so I can spend more one on one time." [Interview]

Mr. W. noted the following barriers, relating to district Internet filters blocking useful resources:

> "Oh no, yeah, that one (the second IA project) kind of failed. Because I think two of the best optimums I found, they (students) found were blocked by the filtering system." [Interview]

> "I found some great resources both on the NSDL & Google. When I set up my lesson at home. When we got into the lab the district filter blocked one of my best sites. I found almost no information or resources on atomic structure. I gave up & picked another unit." [Reflection paper 2]

Case 4, Mrs. B.: low technology knowledge in *tech-only* group. Mrs. B. is junior high school science teacher. Her first IA project was on classification in biology, and her second was on states of matter. She had large gains in her pre to post survey scores, created the largest number of IA projects and collected the most resources (see Table 4). Her second IA project also recorded a large number of student visits. In sum, the TTPD appeared to have strong positive effect on her knowledge and planning activities.

Mrs. B.'s second IA project consisted of a large collection of links with direction on how to access each (see Figure 5). Students had a worksheet of assessment items, and the IA project directed them to answer specific items after interacting with the content on each link. In this way, the IA project did not display elements of PBL, and can be characterized as an offload.

In the following two quotes, Mrs. B. talked about the motivating power of technology and the important of visualizations for student learning:

"Technology is what students like and how they learn. You can't expect students to learn the way we did many years ago. These students like to use computers, search the Web, and play games." [Reflection paper 1]

Mrs. B. described:

"Having students see the position and simulated motion of particles in different types of matter made it easier for them to learn, rather than seeing a diagram in a book." [Reflection paper 1]

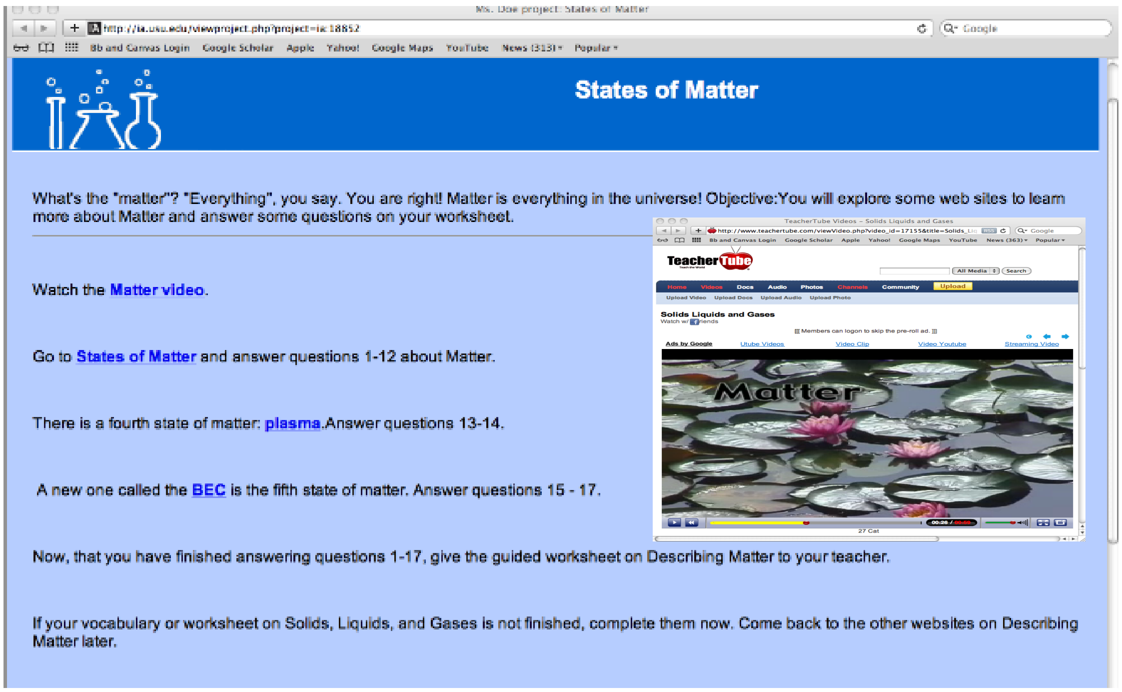

Figure 5. Screenshot of Mrs. B. second IA project.

Mrs. B. also noted that different ability students could use the materials differently when used in a self-paced environment.

"They [students] could replay it over and over. What I learned from my honors class, the honors students only need to see it once. Other students can replay the same video over and over and then it makes the connection. This was another way of presenting the material rather than having the same teacher talking in the same voice, so I think they learned it because it was enjoyable. It was at their pace, they could replay it over and over again." [Interview]

Mrs. B considered the IA as the time saver because it saved her grading time:

"So some handwriting is so illegible, so having students go through the IA was less reading for me to have to go through, less paper work for me, less time for me to have to review and grade papers. For me it was a time saver." [Interview]

Finally, Mrs. B. reported several technology barriers, such as "slow video as everyone tried to access at once, difficulties in reserving the computer lab, lack of computers in classrooms, lack of headphones in lab, and crashing programs." [Reflection paper 2]

Research Question 2: Clarifying Results for Quantitative Study

Case study findings help shed light on results from the quantitative portion of the study. In particular, participants' perceptions on the value of online resources for learning and engagement help explain the gains in pre/post survey scores, as well as the high usage of the IA system.

One participant, Mrs. R., showed the greatest use of PBL elements in IA projects of any participant, showing evidence of impact of the TTPD. She described her approach:

"I was still introducing the idea of density and wanted them to discover some things on their own. I thought this would be a good way to let them explore the topic of density on their own. They were presented with a problem and had to use the resources provided to learn more about density in order to solve the problem the best they could." [Reflection paper 2]

Case study data also revealed that it is difficult to discern use of PBL by examining lesson plans and activities in isolation. For example, Mrs B. deliberately reduced the number of words in her second IA project to accommodate her English language learners. This reduction of content gave the appearance of a much simpler IA project. Similarly, Mr. O.'s second IA project appeared to have little elements of PBL because it only consisted of links to interactive examples of scientific notation. However, as noted above, he wanted students to deduce rules (an inquiry approach) through looking at examples.

Discussion and Conclusion

This article presented four case studies of teachers' experiences designing classroom activities using online resources and the IA after participating in either the *tech-only* or *tech+pbl* TTPD. Using the lens of curriculum adaption and the notion of teachers' varying *pedagogical design capacity* (Brown & Edelson, 2003), we examined teachers' second IA project. We noted that three were categorized as *offload,* while one project showed elements of *improvisation*. In this way, teachers appeared to use a variety of personally relevant strategies when applying TTPD concepts to their contexts.

As discussed above, the *tech-only* TTPD emphasized different aspects of technology integration. Mr. W., a participant with high technology knowledge scores on the pre-survey, talked enthusiastically about how he integrated his IA projects with other technology he regularly uses, notably Google Docs. In this way, he represents an Internet *bricoleur*, mixing and matching tools to best meet his needs. Conversely, Mrs. B., a low technology knowledge participant, recognized her poor technology background, and the importance of professional development opportunities in increasing these critical skills. While Mrs. B. primarily used the IA as a means to collect resources and present these to students, Mr. W. spoke about the value of interactivity and using *Google Docs* to administer student assessments.

In the *tech+pbl* group, Mr. O. saw less value in the TTPD and the IA as a tool, but did note the value of online resources. Conversely, Mrs. R., spoke enthusiastically about the value of online resources in supporting exploration, and the ease of sharing online content with colleagues. More generally, the teachers discussed how they tailored instruction to fit student needs and their interests, and how they incorporated instructional games, activities, and interactive resources to enhance motivation and provide self-paced instruction.

In terms of student learning, participants strongly stated their belief that students prefer to learn with technology, are adept at it, and that using technology could make learning more fun and motivating. This preference was not seen in a negative way, but rather as an increasingly critical factor to consider when designing classroom activities. Participants also expressed, albeit less frequently, a related belief that using technology can help improve student learning. These participants described the way interactive simulations allow students of different ability to "play with" and "see" difficult concepts such as density, motion, and heredity. It also allows students to learn in different ways.

Despite great strides in recent decades in computing access in U.S. schools, all teachers identified several barriers due to technology infrastructure in their schools. Barriers mentioned included district Internet filters, limited access to computer labs, and slow download times. In terms of enablers, three participants also liked the simplicity of the IA, perceiving it as a time saver, valuable for collecting and organizing online resources, and easy to combine with other tools they already knew about for instructional purposes.

In addition, differences were seen between teachers' IA project designs and the resulting classroom implementations. Both participants in the *tech+pbl* TTPD appeared to value PBL as an instructional strategy, but their IA projects differed significantly in presentation. On the surface, Mr. O.'s 2nd IA project appeared to use direct instruction, in that it presented a series of links to online resources. However, in the interview, Mr. O. noted that he wanted students to "discover" rules about scientific notation by having them interact with examples. This finding underscores the importance of not assuming that the designed artifacts reflect subsequent classroom implementations.

Limitations of this study include that findings tended to be descriptive and suggestive due to the qualitative research design. The nature of case study design also leads to generalization issues within research studies (Yin, 2009). In addition, researchers might be biased due to their role as TTPD designers. However, multiple data sources were triangulated in this study and the research findings resonate with previous findings, suggesting the trustworthiness of the interpretations.

In terms of practical implications for teacher professional development providers, our experience supports the view that teachers need explicit support in order to design productively (Brown & Edelson, 2003; Davis & Varma, 2008; Lawless & Pellegrino, 2007). For examples, participants in the *tech+pbl* design were provided with a PBL template embedded in an IA project, which Mrs. R successfully used to designed her second IA project.

Acknowledgements

This material is based upon work supported by the National Science Foundation. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation. We thank the participating teachers in our study, the district science coordinator, and members of the research group.

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