Effects of a Professional Development on Teacher Integration of Online Resources

Xin Mao and Mimi Recker

Abstract The purpose of this study was to investigate the impact of a professional development (PD) workshop on teachers' knowledge and use as related to the integration of online resources. In addition, this study attempted to examine whether teachers' aptitude was a moderating factor in the impact of the PD workshop. Moreover, it explored how teachers used online resources in their practice and how teachers' aptitude might affect their behavior. Based on problem-based learning, the PD workshop was designed to teach in-service teachers the use of a software tool, the Instructional Architect, and the integration of online resources into instructional activities intended for student use. This mixed-method study employed both quantitative and qualitative methods. A quantitative phase of research, a nonequivalent control group pretest-posttest design, as well as a qualitative phase of research, was employed. A repeated measures MANCOVA indicated that the PD workshop had a significant impact on improving teachers' knowledge and use. On the other hand, aptitude was not a moderating factor in the impact of the workshop. In addition, the qualitative phase suggested that while different aptitude teachers behaved similarly regarding how they used online resources, low aptitude teachers appeared to have the most positive attitudes toward the workshop.

Keywords Teacher professional development · Technology integration · Online learning resources · Mixed-method study

Introduction

Professional development of teachers is now recognized as a vital component of policies to enhance the quality of teaching and learning in schools (Ingvarson, Meiers, & Beavis, 2005). With the increasing use of technology in classrooms,

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there is a need for effective professional development that improves teachers' technology integration knowledge and use that ultimately increases student learning outcomes (Lawless & Pellegrino, 2005; Russell, Bebell, O'Dwyer, & O'Connor, 2003). Several studies have suggested that problem-based learning (PBL), an instructional method in which learners learn through engaging authentic and challenging problems in cooperation with their group members (Barrows, 1996), might be an effective approach to train teachers, providing evidence that PBL has the potential to improve teachers' knowledge and use (Albion, 2003; Albion & Gibson, 2000; Butler & Wiebe, 2003; Levin, Hibbard, & Rock, 2002; Ochoa, Kelly, Stuart, & Rogers-Adkinson, 2004). However, a review of the literature found that those studies in the domain of teacher education mostly only used qualitative method. The only quantitative study (Gülseçen & Kubat, 2006) found by the review in this domain did not suggest that PBL-based PD was better than lecture-based PD, although there are quantitative studies showing favorable outcomes for PBL with adult learners in other domains (Doucet, Purdy, Kaufman, & Langille, 1998). Meanwhile, as documented by the research, teachers' aptitude may have a moderating role in the impact of PBL-based PD on teachers' knowledge and use (Hmelo-Silver, 2004). Additional research is needed to employ methods beyond the qualitative method and consider teachers' aptitude as an influencing factor.

On the other hand, recently researchers have stated that the widespread availability of online learning resources on the World Wide Web, as one kind of educational technology, hold great potential for transforming education (Lawless & Pellegrino, 2005; Recker, Dorward, Dawson, Mao, et al., 2005). "Through interacting with Web content, students can now engage in highly personalized learning experiences, instead of relying on the one-size-fits-all textbook" (Recker, Dorward, Dawson, Mao, 2005, p. 197). In recognition of this, many digital libraries have been developed to provide teachers with catalogued collections of high quality online resources (Recker et al., 2007). The NSF-funded National Science Digital Library (NSDL.org), as a prominent example, is intended to increase the use of online learning resources and ultimately improve teaching and learning, specifically in science, technology, engineering, and math (STEM) disciplines (Recker et al., 2007). However, few studies have investigated how teachers' knowledge and use are changed as a result of their interactions with these online resources, and how teachers adapt, design, and reuse the resources in their classrooms (Recker, Dorward, Dawson, Mao, et al., 2005; Recker et al., 2007).

This chapter presents a mixed-method study, employing both quantitative and qualitative methods, which investigated teachers' changes in knowledge and use after they participated in a PBL-based professional development workshop that taught them integration of online resources. We looked for evidence of whether teachers had increased in their knowledge and use of online resources, how they designed and implemented instructional activities around online resources, and whether and how their aptitude influenced the impact of the PD workshop on their knowledge and use. The study was part of the Utah State University's Digital Libraries go to Schools (DLConnect.usu.edu) project (Recker et al., 2007)

Teacher Technology: The Instructional Architect

Teachers participating in this study learned to use the Instructional Architect (IA.usu.edu) as part of the professional development activities. The IA is a simple end-user authoring service, which allows teachers to use, find, and share online resources from the National Science Digital Library and the Web, and create engaging and interactive instructional activities or IA projects around the online resources (Recker, Dorward, Dawson, Halioris, et al., 2005). Figure 1 shows an example of an IA project created by teachers using the IA tool. The foreground of the figure shows one of the teacher's selected online resources. The background shows the output of using IA: a web page containing the content created by the teacher, consisting of activities and annotations for online resources (referred to by links).

Teachers can use the IA in several ways. In the "My Resources" area of the IA, teachers can directly search for and save STEM resources from the NSDL Data Repository (NDR). Teachers can also select any Web resource 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 in which they select a look and feel for their project, input selected online resources and provide accompanying text. Finally, teachers can "Publish" their projects for only their students, or the wider web world.

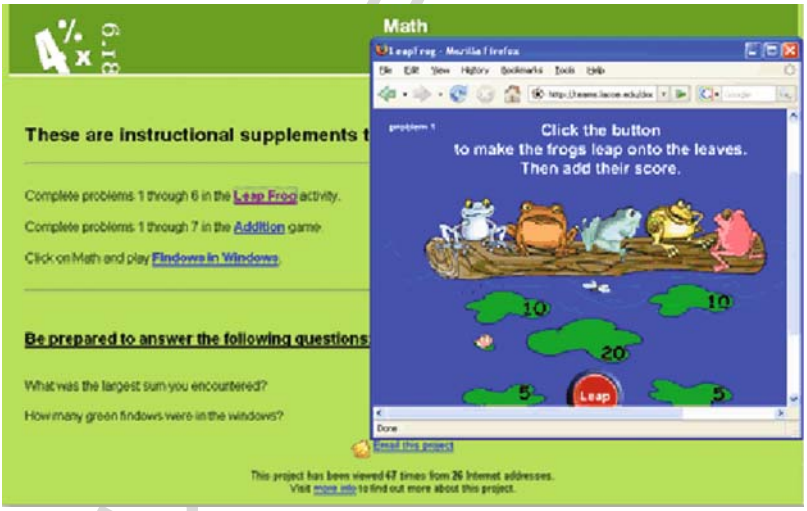

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Fig. 1 Demonstration of an IA project and within online resources The author's name of the project has been removed to protect his/her privacy.

Theoretical Framework

In this section, firstly we introduce the framework for this study. Then we describe the professional development model used in this study. Furthermore, we introduce the design continuum we adopted to analyze how teachers designed instructional activities using online resources.

Because mixed methods research can incorporate the strengths of both quantitative and qualitative methodologies (Johnson & Onwuegbuzie, 2005), this study employed them both. Figure 2 shows the framework for this study. As seen in Fig. 2, the PBL-based PD workshop was used as the intervention. The construct "knowledge" was quantitatively measured in terms of the participants' understanding of the concepts about online resources and use of the IA. The construct "use" was both quantitatively and qualitatively measured. First, it was quantitatively measured in terms of the participants' self-reported use of online resources. Then, it was qualitatively examined in terms of how the participants designed and implemented their IA projects. The participants' aptitude as related to their knowledge, comfort, and experience with technologies was assumed to be a moderating factor in the impact of workshop participation on their knowledge and use of online resources.

PBL-Based Professional Development

The main focus of the PBL-based PD workshop was to teach the teachers to design and implement classroom instructional activities (or IA projects) through using the Instructional A[illegible]ect. By blending technological skills with classroom practice, the PBL-based workshop not only prepared the teachers to master the basic technology skills such as searching for online resources, and creating an IA project, but was also intended to promote the teachers' pedagogy as related to strategies for the integration of online resources in their classrooms.

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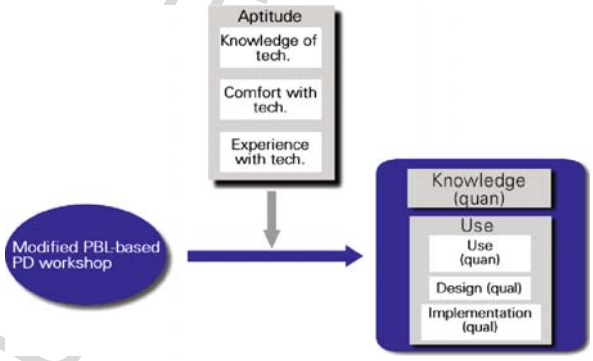

Fig. 2 Framework for the study

By following Barrows' PBL framework (Barrows, 1996), the workshop provided the teachers with problems that were authentic and situated in their practices, opportunities to direct their learning, and collaborative opportunities to discuss and share their experiences and practices. Meanwhile, several modifications were implemented, also called modified PBL strategies, primarily following Jonassen's (1997) problem solving framework and van Merriënboer et al.'s 4C/ID model (van Merriënboer, Clark, & de Croock, 2002). AQ1

First, Barrows' framework of PBL suggested presenting a problem at the beginning. Instead, this workshop presented the introduction of the IA and the basic steps involved in creating an IA project first. Second, Barrows advocated for a very specific and purposeful selection and sequencing of problems to promote learning. This workshop provided various small problems that ranged from more structured and simple (e.g., creating a simple IA project) to more ill-structured and complex (e.g., designing an advanced IA project). And the teachers selected the problems on their own. Third, as stated in Barrows' framework of PBL, learners should work cooperatively in groups to seek solutions to real world problems. However, the group processes in this workshop were not as involved as in a standard PBL implementation. During this workshop, the teachers were involved in a variety of group processes such as reflection on problem solutions to interact with peers, but there was no meaningful interaction in terms of working collaboratively to find out problem solutions. Fourth, Barrows' framework of PBL provided learners with minimal guidance. This workshop provided scaffolding (e.g., checklist, just-in-time help) to support the teachers' learning. As the problems became more complex, as teachers presumably gained more skill, the scaffolding decreased. Fifth, different from Barrows' framework of PBL, this workshop provided the teachers with opportunities to reflect on their practice. The final reflective phase (e.g., revising previous IA project based on the feedback from group members) asked them to summarize what has been learned and to integrate it with their prior knowledge.

Design Continuum

Brown and Edelson's perspective (2003), teaching as design, was used to explore how the participants designed their IA projects by incorporating online resources. Brown and Edelson (2003)'s perspective of "teaching as design" suggested that teachers designed instruction by using the curriculum resources as resources. They defined teachers' use of curriculum resources on a continuum, ranging from offloading to adaptation to improvisation. In offloading, the curriculum resources are adopted essentially unchanged. While in improvisation, the teacher flexibly borrows and customizes pieces. The adaptation category represents the mid point of the continuum. Online resources, representing one kind of curriculum resources, could support and constrain the instructional activities designed by teachers. By adapting Brown and Edelson (2003)'s framework to the context of online resource usage, this study defined the design continuum as Table 1 shows.

Table 1 Descriptions and examples of the design continuum

	Description
Offloading	There was little added teacher-created content beyond the links of resources. Use tends toward simple links to resources with added navigational information.
Adaptation	A midpoint, with some of the elements listed below.
Improvisation	The objectives of the instructional activity are clear; The project has a clear structure as an instructional activity, as comprised of objectives, the links of resources, teacher-added instructional content, and assessment; The instructions on how to use the resources are clear.

Purpose of the Study

The purpose of this study was to investigate the impact of a PBL-based professional development workshop on teachers' knowledge and use. Specifically, this study addressed the following three research questions.

1. Was there an impact of the modified PBL-based PD workshop on improving teachers' knowledge and use with regard to their integration of online resources?
2. Was teachers' aptitude a moderating factor in the impact of the modified PBL-based PD workshop on their knowledge and use?
3. How did teachers use online resources in their practice as a result of participating in the workshop? How did teachers' aptitude moderate the impact of the workshop on their behavior?

This study is significant in that it contributed to research on the impact of PBL-based PD workshops. First of all, it used a design of mixing quantitative and qualitative methods and approaches, as well as different data collection approaches. Moreover, it directly linked the goal of the modified PBL-based PD workshop to teachers' learning outcomes. With regard to the existing studies, while the objectives of the professional development programs were helping teachers improve their knowledge and use, the studies usually did not examine teachers' learning outcomes (Fishman, Marx, Best, & Tal, 2003). In addition, this study added to the knowledge base by considering teachers' aptitude when investigating the effects of the modified PBL-based professional development.

Methods

Design

This study adopted a mixed-method and mixed-model design (Johnson & Onwuegbuzie, 2005), employing a quantitative phase of research and a qualitative phase of research, as well as mixing quantitative and qualitative approaches within each

phase. According to the five major purposes of conducting mixed method research proposed (Greene, Caracelli, & Graham, 1989), the purpose of such a design was primarily expansion. That is, it sought to expand the breadth and range of research by using different methods for different inquiry components.

A quantitative phase of research was used to address the first two research questions and a qualitative phase of research was used to address the third research question. The quantitative phase of research, a nonequivalent control group pretest-posttest design, consisted of a treatment group ($N = 48$) and a control group ($N = 41$). The participants enrolled in two online courses formed the treatment group. They were trained using the modified PBL-based professional development workshop. The control group was comprised of participants enrolled in one other online course. The control group only took the four-part pre-survey and two-part post-survey, without receiving any training using the modified PBL-based PD workshop. The independent variable was the group assignment. The dependent variables were the participants' knowledge and ~~skills~~, And the participants' self-reported aptitude was used as a covariate.

With regard to the qualitative phase of research, we performed an in-depth analysis on the treatment group participants' use of online resources. Specifically, the content and use of participants' IA projects, reflection papers, and discussion posts, were analyzed. A case study was further conducted by purposively selecting seven participants for an in-depth analysis of their implementation. Moreover, the qualitative phase of research was used to explore how different aptitude participants behaved differently.

Participants

The participants in the quantitative phase of study were those who enrolled in three online courses at a state university during the fall semester of 2006. They mostly consisted of in-service elementary, secondary, high, and post-secondary school teachers. One of the 48 treatment group participants did not complete the workshop. Of the remained 47 treatment group participants, 38 (79%) participants finished both the pre-survey and the post-survey. Of the 41 control group participants, 15 (37%) participants finished both surveys. Because some participants did not have opportunities to use online resources in classrooms and some participants' responses to the pre-survey and the post-survey did not meet the timeline requirement, we further limited these participants by examining their responses to the demographic survey (i.e. as one part of the pre-survey). 22 treatment group participants and 13 control group participants remained for the quantitative phase of research. Table 2 displays the participant demographics.

Treatment

The treatment was the PBL-based PD workshop offered to the treatment group participants, inservice K-12, post-secondary, and seminary teachers. The instructional

316 **Table 2** Demographic characteristics of the participants

Characteristics	Treatment group ($N = 22$)	Control group ($N = 13$)
Teaching Years		
5 or less	12 (54.55%)	6 (46.15%)
6–10	5 (22.73%)	4 (30.77%)
11–15	4 (18.18%)	3 (23.08%)
16 or more	1 (4.54%)	0
Occupations		
K-12 classroom teachers	12 (54.55%)	11 (84.62%)
K-12 librarians/media specialists	8 (36.36%)	0
College instructors	2 (9.09%)	2 (15.38%)
Grade Levels		
Elementary	7 (31.82%)	1 (7.70%)
Secondary	13 (59.09%)	10 (76.92%)
College	2 (9.09%)	2 (15.38%)

condition was conducted in a WebCT, a learning management system. The treatment materials consisted of primarily three sections, the syllabus, the content module, and the discussion board, all of which were conducted as a WebCT course. The syllabus provided the participants with an introduction to the workshop and its expectations. The content module was the primary section of the workshop curriculum. It included the following sections: introduction to the IA and how to browse IA projects, create an IA account, basic steps to create an IA project, connect to core curriculum, online resources, design IA projects, implement IA projects, comment on others' IA projects, modify IA projects, and conclusion. The discussion board allowed the participant to share, discuss information and experiences with his/her group members, while he/she worked individually on the workshop problems and activities.

Each participant was asked to create at least one IA project for implementation in a classroom setting. Moreover, the participant needed to modify the implemented project or create a new project during the workshop. Then the participant was required to post the URL of the projects he/she created or modified/re-created to the discussion board. In addition, each participant was asked to submit a reflection paper to the discussion board upon the completion of the workshop. In the reflection paper, the participants primarily provided an image of how they implemented their IA projects in an instructional situation, along with some design issues.

Instrument

There were four instruments used in the study (see Table 3). In the following discussion of the instruments, we describe the design parameters for each, as well as efforts to establish validity and reliability.

Table 3 Instruments

Name	Construct	Time period	No. of items	Type	Reliability coefficients
Demographic survey	Demographic info	Pre-survey	8	Short answer	/
Aptitude survey	Prior aptitude	Pre-survey	16	Likert scale	Cronbach's alpha = 0.899
Knowledge test	Knowledge	Pre-survey and post-survey	5 (pre) 5 (post)	Combination of multiple choice and open-ended response	Pearson's r = 0.978 (pre) & 0.966 (post)
Use survey	Use	Pre-survey and post-survey	4	Combination of Likert scale and open-ended response	Cronbach's alpha = 0.703

Demographic survey. This instrument, as part of the four-part pre-survey, was designed to understand the treatment and control group participants' demographic characteristics. This included: (a) years of teaching experience, (b) grade level taught, and (c) position at schools.

Aptitude survey. This instrument, as part of the four-part pre-survey, was designed to measure the entering aptitude of the treatment and control group participants as related to self reports of their (a) knowledge of computers and the Internet, (b) comfort with computers and the Internet, and (c) experience with computers and the Internet in their professional life. In terms of the first subset and the second subset, the five responses that the teachers could choose from ranged from 0 = very low to 4 = very high. Four responses ranged from 0 = very low to 3 = very high for the third subset. The highest possible mean score was 3.69 (59/16) and the lowest possible mean score was 0.

This instrument was adapted from the surveys developed by Becker and Anderson (1998) and Russell and his research group (Russell, Bebell, & O'Dwyer, 2003). In an effort to test the reliability of this instrument, we conducted a test of internal consistency using a Cronbach Alpha test. It reported that the reliability of this instrument was high with 0.899 as the reliability coefficient.

Knowledge test. We developed this instrument to test the knowledge of the treatment and control group participants. Specifically, this test measured their understanding of the concept of online resources, searching techniques, criteria for determining high-quality online resources, and the Instructional Architect. The participants responded by selecting from a multiple choice list or by typing in a short answer. The posttest for this section was basically the same as the pretest of this section. The only difference between them was that one item was replaced in the posttest to see whether the teachers had acquired knowledge regarding online resources and the IA after the treatment. The strongest total score was both 8 points for the pretest and the posttest.

This instrument was developed by the IA team. It was reviewed by a panel of 6 professionals, which included those who are professionals in the ~~online~~ workshop content and those who are professionals in educational assessment. Upon review by the panel, slight changes were made for greater clarity. With regard to the reliability of this instrument, two raters scored half of the tests and had negotiations on the scoring key to determine the interrater reliability of this knowledge test. In calculating the interrater reliability, the ultimate reliability coefficient was 0.978 and 0.966 for the pretest and the posttest, respectively.

Use survey. The use survey was intended to measure the participants' use of online resources and online lessons before and after the treatment. This instrument was a combination of Likert scale and open-ended questions that collected self-reported data from both the treatment group and the control group. The post-survey for this section was identical to the pre-survey of this section. The two Likert scale items had anchors from 0 = very low to 4 = very high. The two open-ended questions asked the participant to self report how often he/she presented online resources to his/her students in the last two weeks and how often he/she let the students use online resources in the last two weeks. Because there was a need to examine the participants' responses for the four items on the same scale, we scaled the participants' responses for these two items to 0–4 Likert scale, that is, 0 = none, 1 = 1–5, 2 = 6–10, 3 = 11–15 and 4 = more than 15. The highest possible mean score was 4 and the lowest possible mean score was 0.

This instrument was adapted from the survey developed by the IA team. Therefore, the construct validity of this instrument was anchored in literature. In an effort to test the reliability of this instrument, we conducted a test of internal consistency using a Cronbach alpha test on the pre-survey and the post-survey, respectively. The reliability coefficient was 0.703 by using the reliability for the pre-survey. This suggested that the reliability of this instrument was good as there were only four items.

In addition to the data collection described on the preceding pages, we employed an analysis of IA projects to understand how the participants designed IA projects using online resources across time. We also analyzed the participants' reflection papers and discussion posts to explore how they implemented their IA project(s) in a classroom setting.

Data Analysis

Quantitative Phase of Study

In an effort to address the first two research questions, a repeated measures multivariate analysis of covariance (MANCOVA) testing two-way interaction and a repeated measures MANCOVA testing three-way interaction were conducted using SPSS. The between-groups variable was the intervention (i.e., represented as group). The covariate was the aptitude (i.e., represented as aptitude). The within-groups variable was time, time1 and time 2 (i.e., represented as time). The two dependent

variables were the total scores on the knowledge test (i.e., knowledge) and the average scores on the use survey (i.e., use).

Qualitative Phase of Study

The data analysis for the qualitative phase of research was comprised of an analysis of IA projects and a case study analysis of several participants. In terms of the former, the purpose was to explore how the participants incorporated online resources into IA projects as designers. With regard to the latter, we were interested in understanding how the participants implemented their projects in classrooms. Moreover, how the participants' aptitude related to their design and implementation of IA projects was explored. The data analysis involved processes such as organizing the data, coding the data, converting the data, generating patterns, offering interpretations, and writing the report. Mixed approaches were employed, for example, the qualitative data (i.e., via coding) were converted to numerical codes that could be represented quantitatively.

Results and Findings

Repeated Measures MANCOVA

A repeated measures MANCOVA was conducted to answer the first two research questions: (a) was there a significant interaction effect between time and group? and (b) was there a significant interaction effect between time, group, and aptitude?

First, in order to address the first research question described above, a repeated measures MANCOVA was performed testing the interaction between group and time with aptitude as a covariate. The results suggested that there was a significant interaction between time and group on knowledge and use as a whole ($F = 5.18$, $p < 0.05$, $ES = 0.25$; see Table 4). This indicated that changes with regard to knowledge and use across time were significantly different for the teachers in the two groups.

Moreover, the univariate effects of the interaction between time and group on both knowledge ($F = 4.99$, $p < 0.05$, $ES = 0.135$) and use ($F = 7.035$, $p < 0.05$, $ES = 0.18$) were significant (see Table 4). In terms of the effect on the teachers' knowledge, both the treatment and control group teachers increased their knowledge while the treatment group scores (from 3.32 to 5.14) increased more than those of the control group (from 2.46 to 3; see Table 5). With regard to the effect on their use, as both groups had a similar entering average score, 1.51 and 1.52, respectively, mean scores for the treatment group increased to 1.80 after the intervention, while the control group decreased to 1.36 over time (see Table 5). Specifically, the treatment group increased 20% (from ~~1.5~~ ^ to 1.8) regarding their use of online resources.

On the other hand, in an effort to address the second research question, a repeated measures MANCOVA was performed testing the three-way interaction between time, group, and aptitude. The results indicated that

Table 4 Univariate and multivariate interaction and main effects for a repeated measures MANCOVA testing two-way interaction

	Univariate				Multivariate		
Effects	Dept. var.	*F*	*P*	*ES*	*F*	*P*	*ES*
Time × Group	Knowledge	4.99	0.033*	0.135	5.18	0.011*	0.25
	Use	7.035	0.012*	0.18			
Time	Knowledge	4.178	0.049*	0.115	2.893	0.07	0.157
	Use	2.522	0.122	0.073			
Group	Knowledge	23.436	0**	0.423	15.364	0**	0.498
	Use	3.319	0.078	0.094			

* $p < 0.05$
** $p < 0.01$

Table 5 Group means (SD) at pre-survey and post-survey for variables (N = 22 in treatment group, N = 13 in control group)

	Data collection point	
Variable	Pre-survey	Post-survey
Aptitude survey		
Treatment group	2.37 (0.62)	–
Control group	2.46 (0.57)	–
Knowledge test		
Treatment group	3.32 (1.04)	5.14 (1.46)
Control group	2.46 (1.05)	3 (0.91)
Use survey		
Treatment group	1.51 (0.66)	1.80 (0.53)
Control group	1.52 (0.75)	1.36 (0.62)

both the multivariate ($F = .760$, $p > 0.05$, $ES = 0.05$) and univariate effects (knowledge: $F = 0.630$, $p > 0.05$, $ES = 0.04$; use: $F = 1.177$, $p > 0.05$, $ES = 0.07$) of interaction between time, group, and aptitude were not significant (see Table 6). In addition, as seen from Table 6, there was not a significant time-by-group interaction any more, because the inclusion of the three-way interaction weakened this effect and there was not enough test power (sample size) to retain the significance.

In summary, the modified PBL-based PD workshop had a significant impact on improving the teachers' knowledge and use. However, the teachers' aptitude did not significantly moderate the impact of the workshop on their knowledge and use.

Findings of the Analysis of IA Projects

The emphasis in the analysis of IA projects was on investigating the ways the participants designed with online resources. It also examined whether there were changes between the projects created at time1 and those created or modified at time 2. It

Table 6 Univariate and multivariate interaction and main effects for a repeated measures MANCOVA testing three-way interaction

	Univariate				Multivariate		
Effects	Dept. var.	*F*	*P*	*ES*	*F*	*P*	*ES*
Time × Group x Aptitude	Knowledge	0.630	0.539	0.039	0.760	0.556	0.05
	Use	1.177	0.322	0.071			
Time × Group	Knowledge	0.003	0.955	0	0.002	0.998	0
	Use	0.001	0.980	0			
Time	Knowledge	4.203	0.049*	0.119	3.044	0.063	0.169
	Use	2.819	0.103	0.083			
Group	Knowledge	0.975	0.331	0.031	1.006	0.378	0.063
	Use	0.682	0.415	0.022			

*$p < 0.05$

should be noted that the time 2 version of the projects was identified by examining the last version of the projects re-created or modified during the workshop. Finally, the relationship between the participants' aptitude and their behavior was explored.

Analysis of aptitude level. We classified each treatment group participant into high, medium, or low aptitude level to understand how the participants with different aptitude levels performed differently with regard to the design and implementation of IA projects. The 25th percentile (2.0625) and the 75th percentile (2.89) were used as the thresholds for the high and low aptitude level, respectively. Therefore, the mean aptitude that was 2.0625 or lower was defined as the low aptitude level; the mean aptitude that was 2.89 or higher than defined as the high aptitude level; the medium aptitude level referred to the mean aptitude that was between 2.0625 and 2.89. In summary, six participants had high aptitude levels, 13 participants had medium aptitude levels, and seven participants had low aptitude levels.

Analysis of IA projects. By examining the projects the participants submitted, it turned out that 10 (38%) participants revised their previous projects, eight (31%) participants created new projects, three (12%) participants both revised and re-created projects, and five (19%) participants neither revised nor re-created their projects. Therefore, 13 (10+3) projects between time1 and time 2 showed differences in terms of revision and 11 (8+3) projects were re-created. We separately analyzed 13 revised projects and each of the 11 re-created projects at both their time1 and time 2 versions. Moreover, the five projects without revision or re-creation were analyzed for their time1 version. Specifically, these projects were coded into one category of the design continuum (offload, adaptation, or improvisation, see Table 1). The aptitude level of the author (participant) corresponding to each project was also coded into one category of the aptitude continuum (low, medium, or high).

In order to test the reliability of coding the data, two coders used the design continuum to code the time1 version and time 2 version of each of 13 randomly selected projects that experienced revision or re-creation. Although there were discrepancies in the beginning regarding the ways in which the two coders coded the

projects, they were resolved after a discussion and a 100% inter-rater reliability was achieved. Finally, we applied the final coding scheme on the remaining projects.

The two coders clarified during the coding procedure that: (1) in terms of the improvisation category, the assessment was accepted when it was evident that students using the IA projects were asked to submit some work to the participant (i.e. the project author), such as reflection papers, answer sheets, and so forth; (2) in terms of the improvisation category, it was required that there were instructions on use of resources. This focused on whether it was clear regarding how to use those online resources. Therefore, although in some project links to resources were listed, the project was classified as improvisation since the purpose was to ask students to discover information from those resources and the project author had made it clear how to use them; (3) in terms of the offloading category, links to resources were provided primarily for student view. The project contained few instructional elements.

Table 7 shows the number and percent of projects falling into each category of both the design and aptitude continuums. As Table 7 shows, while most participants appeared to master the incorporation of online resources into IA projects, there were little changes between time1 and time 2 with regard to the design continuum. When connecting the participants' aptitude to their projects on the design continuum, there were interesting findings. All of the low aptitude participants made changes to their projects. The high and medium aptitude participants tended to revise projects while the low aptitude participants tended to re-create projects. This suggests that low aptitude participants were more willing to invest time and effort in the workshop than medium and high participants.

Table 7 Number (%) of projects in design and the aptitude continuums for time1 and time 2

No. of projects	Time1					Time 2				
5 projects		L	M	H[1]	Total	–				
	O	0	0	0	0	–				
	A	0	1(20)	1(20)	2(40)	–				
	I[2]	0	2(40)	1(20)	3(60)	–				
		0	3(60)	2(40)		–				
13 revision Projects		L	M	H	Total		L	M	H	Total
	O	0	2(15)	0	2(15)	O	0	2(15)	0	2(15)
	A	2(15)	1(8)	1(8)	4(31)	A	2(15)	1(8)	1(8)	4(31)
	I	1(8)	4(31)	2(15)	7(54)	I	1(8)	4(31)	2(15)	7(54)
		3(23)	7(54)	3(23)			3(23)	7(54)	3(23)	
11 re-creation projects		L	M	H	Total		L	M	H	Total
	O	0	0	0	0	O	1(9)	1(9)	0	2(18)
	A	4(36)	1(9)	1(9)	6(54)	A	3(27)	1(9)	0	4(36)
	I	3(28)	2(18)	0	5(46)	I	3(28)	1(9)	1(9)	5(46)
		7(64)	3(27)	1(9)			7(64)	3(27)	1(9)	

[1]L, M, and H represent low, medium, and high aptitude level, respectively.
[2]O represents offloading, A represents adaptation, and I represents Improvisation.

It is important to note that the analysis of IA projects as discussed above was primarily aimed at describing how the participants incorporated online resources into their projects across time, rather than assessing the quality of those changes. Therefore, the design continuum was not a quality continuum, and, as such, improvisation doesn't necessarily imply a higher quality project than adaptation and offloading.

Findings from the Case Study

We also conducted a case study on several purposively selected participants to provide an image about the context surrounding the IA project(s) each of them implemented, and how the participants implemented the project(s) in their classrooms, as well as the relationship between their aptitude and implementation. In this analysis, we selected seven participants based on a stratified purposeful sampling procedure (Gall, Borg, & Gall, 1996), using the participants' aptitude as the stratification variable. As described previously, we first conducted an analysis of aptitude level. Then we randomly selected 25% participants (cases) from each aptitude level. Information was collected from the document analysis of reflection papers describing a variety of issues related to the selected participants' application. In addition, the analysis of the selected participants' IA projects and discussion threads were corroborated with the analysis gathered from their reflection papers. There were two major themes emerged from the analysis.

Facilitating and improving student learning. As the participants stated in their reflection papers, the IA projects or instructional activities implemented by them seemed to facilitate and improve student learning. First, they reported that the students enjoyed using online resources to tackle real-world tasks. One participant reported that "some of the students liked doing the project and were diligent about looking at the websites and completing the assignment." Another participant commented that "the students were engaged in the websites and the information within those websites" (quotes from the reflection paper), and they all completed the task easily. A survey conducted by a participant indicated that her students generally had positive attitudes toward the IA project or instructional activity. Moreover, the students had a gain of knowledge or skills throughout the instructional activities. Another participant reported that overall her students improved their skills, which she attributed the gain to the project she implemented. These indicated that the participants' implementation were relatively successful.

Holding different attitudes with different aptitude levels. Perhaps the most intriguing issues to emerge from this case study analysis of selected participants were those associated with the themes which focus on the relationship between the participants' aptitude and their attitudes. The low aptitude participants appeared to be the most active participants in the workshop module, and the participants who expressed the most interest in the Instructional Architect. One low aptitude participant thought the workshop was very helpful. Two low aptitude participants commented that the IA bypassed time-consuming and unproductive processes, most

notably searching for resources. And they both had fun doing these projects. The high aptitude participants, by contrast, appeared to be the most inactive participants in the workshop. Some of them were not satisfied with IA functionality, as they expected more features to be able to design their projects. The medium-aptitude participants, neither held attitudes as positively as the low-aptitude participants toward the IA nor appeared to be uninterested in the IA as the high aptitude participants. The findings indicated that different aptitude participants exhibited different attitudes towards the workshop. However, there was little evidence to suggest that which level of aptitude participants might benefit more than other aptitude participants from the workshop with regard to their knowledge and use.

Conclusions and Discussion

Because the mixed-method and mixed-model design was an expansion design, the first two research questions and the third research question investigated different inquiry components. The data collected during the course of the inquiry point to four conclusions. The first two conclusions shed light on the research questions 1 through 2 which seek to understand whether there was an impact of the workshop on improving teachers' knowledge and use, and whether teachers' aptitude was a moderating factor. In seeking to answer these two questions, a quantitative phase of research was conducted and the analyses yielded the following conclusions.

First, as indicated by a repeated measures MANCOVA testing the interaction between time and group, the modified PBL-based PD workshop had a significant impact on improving teachers' knowledge and use. This is consistent with what the research suggested. It has been documented that PBL might be an effective instructional approach (Dochy, Segers, Van den Bossche, & Gijbels, 2003; Gijbels, Dochy, Van den Bossche, Segers, 2005). One quantitative study showed significantly favorable outcomes for a PBL group in the domain of adult education (Doucet, Purdy, Kaufman, & Langille, 1998).

Second, a repeated measures MANCOVA testing the three-way interaction between time, group, and aptitude did not show that teachers' aptitude significantly influenced the impact of the workshop on their knowledge and use. While some research suggested that learners' aptitude might influence their performance in a PBL learning environment (Mergendoller, Bellisimo, & Maxwell, 2000; Mergendoller, Maxwell, & Bellisimo, 2006), the small sample size especially for the control group ($N = 13$) could account for this result.

The final two conclusions addressed the research question 3. In seeking to answer this question, a qualitative phase of research was conducted and the analyses yielded the following conclusions.

Third, the analysis of IA projects revealed that many teachers incorporated online resources into their IA projects by adding necessary instructional content instead of only listing online resources.

Fourth, while different aptitude teachers behaved similarly with regard to the way they designed and implemented IA projects by incorporating online

resources, low aptitude teachers appeared to have more positive attitudes toward the modified problem-based learning environment than high aptitude teachers.

In summary, the findings from the qualitative phase of research were in line with the results of the quantitative phase of research. The analysis of the IA projects suggested that all the teachers appeared to master the skills of incorporating online resources into IA projects, although there were little changes between the projects designed across time. The case study revealed that most of the teachers agreed that the students learned what they needed to learn, indicating that the teachers' design and implementation were relatively successful. Therefore, the qualitative phase of study also indicated that the workshop had a positive impact on teachers' knowledge and use. Despite this, more evidence is needed to indicate that those positive behaviors resulted from the workshop. Firstly, there was a lack of a comparison of the behaviors between the treatment group and the control group. Secondly, there was a lack of sustained investigations regarding how those teachers used online resources in practice. As Lawless and Pellegrino (2005) suggested, sustained or follow-up studies on teachers' behaviors in practice are important to reveal the impact of a workshop model.

With regard to the role of teachers' aptitude in the impact of the workshop, the qualitative phase of research echoed the quantitative phase of research, showing that different aptitude teachers behaved in similar ways regarding the way they incorporated online resources into IA projects and how they implementation IA projects in classrooms. We did find that high aptitude teachers did not create any offloading projects. However, this only suggested that high aptitude teachers were different from low and medium aptitude teachers at the entering level, since the analyses did not reveal any changes to the projects designed across time between different aptitude teachers. Interestingly, there was an emergent finding from the qualitative phase of research, suggesting that low aptitude teachers seemed to have the most positive attitudes toward the workshop and the IA. Previous research suggested that learners with high aptitude may be more willing to accept ill-structured treatments (e.g., low external control, implicit sequences and components) such as PBL than low aptitude learners (Kirschner, Sweller, & Clark, 2006; Snow & Swanson, 1992). One response to the contradictory finding is that the PBL-based PD workshop in this study was a modified PBL-based workshop, and not a true ill-structured treatment. Another implementation is that there needs to be further evidence as few empirical studies have investigated this issue.

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Chapter 7

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