Extended Professional Development in Project-Based Learning

Impacts on 21st Century Skills Teaching and Student Achievement

West Virginia Department of EDUCATION
Office of Research
Division of Curriculum and Instruction

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Nate K. Hixson

Jason Ravitz

Andy Whisman

West Virginia Department of EDUCATION
Office of Research

West Virginia Department of Education
Division of Teaching and Learning
Office of Research
Building 6-Room 722 State Capitol Complex
1900 Kanawha Boulevard East
Charleston, WV 25305
http://wvde.state.wv.us/

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Jorea M. Marple
State Superintendent of Schools
West Virginia Department of Education

Robert Hull
Associate Superintendent
West Virginia Department of Education

Larry J. White
Executive Director
Office of Research

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Keywords

Project-Based Learning, Professional Development, Standardized Testing, Student Performance

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Content Contact
Nate Hixson
Assistant Director
Office of Research
nhixson@access.k12.wv.us

Abstract

From 2008 to 2010, project-based learning (PBL) was a major focus of the Teacher Leadership Institute (TLI), undertaken by the West Virginia Department of Education (WVDE), as a method for teaching 21st century skills. Beginning in January 2011, a summative evaluation was conducted to investigate the effect of PBL implementation on teachers' perceived ability to teach and assess 21st century skills and on student achievement.

Method of study. We conducted a survey of teachers who (a) were trained in PBL at TLI by Buck Institute for Education (BIE), (b) had been identified as experienced users because they had successfully published a project in the state's peer-reviewed project library, and (c) used PBL during the spring semester of SY2011. The survey responses of the final sample of 24 trained PBL-using teachers were compared to a matched group of teachers with similar backgrounds and teaching assignments who did not use PBL or who had used it but had limited or no professional development and had not participated in the BIE training. WESTEST 2 achievement gains in English/language arts, mathematics, science, and social studies were compared for students of the two groups of teachers.

Findings. Overall, there were substantial and statistically significant effect size differences between teachers who used PBL with extended professional development and other teachers in the sample. Compared with the matching group, the extensively trained PBL-using teachers taught 21st century skills more often and more extensively. This finding applied across the four content areas, in classrooms serving students with a range of performance levels, and whether or not their schools had block scheduling. The study also found that teachers did not feel as successful at assessing the skills as they did teaching them.

Students of these teachers performed no differently on WESTEST 2 than a matched set of students taught by non-PBL-using teachers or teachers who had not received extensive training. Although these results did not show significantly different gains, they should serve to mitigate the concern among some educators that engaging in PBL will impede standardized test preparation. This study also provided evidence of the potential of PBL to become part of the larger educational landscape by working in different types of schools.

Limitations of study. All studies of this nature that involve voluntary teacher participation in professional development and implementation have a risk of self-selection bias. Survey responses were based on teacher perceptions regarding a "target class"; consequently they do not necessarily represent the breadth of instruction provided by the sampled teachers in all of their course offerings. Due to relatively low sample sizes and small effect sizes, the achievement test analyses were afflicted by low statistical power. When we aggregated our data (across content areas) the result approached significance, but the difference between groups was still quite small in practicality.

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Introduction

From 2008 to 2010, project-based learning (PBL) was the focus of a major professional development effort, the Teacher Leadership Institute (TLI), undertaken by the West Virginia Department of Education (WVDE).

TLI is an annual yearlong professional development experience, with an intensive week-long residency, to support teams of teacher leaders from each county. The county teams trained at TLI are charged with assisting the county leadership as they build capacity for 21st century learning experiences for students and their teachers. According to WVDE Office of Instruction staff, the collaborative school teams focus on creating engaging instructional designs and their delivery "to improve student achievement while transforming the culture of the school to support collaboration, communication, problem solving, creativity, and critical thinking among students and teachers" (WVDE, n.d.). Throughout the year, the office provides monthly webinars to support the TLI teams.[1]

All PBL professional development provided during this period was conducted in partnership with the Buck Institute for Education (BIE), a nonprofit group founded in 1987 that has focused since the late 1990s on the provision of high-quality PBL professional development.[2]

PBL is an approach to instruction that can vary depending on grade level and subject area. Mergendoller, Markham, Ravitz, and Larmer (2006) have provided a general definition that captures many important characteristics of PBL. They explain that PBL is "a systemic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process that is structured around complex, authentic questions and carefully designed products and tasks" (p. 587). In other words, while allowing for some degree of student voice and choice, teachers carefully plan, manage, and assess rigorous projects to help students learn key academic content and develop 21st century skills.

Twenty-first century skills as defined in West Virginia 21st Century Content Standards and Objectives (West Virginia Board of Education, 2008) include the following:

> *Standard 1: Information and Communication Skills*—The student will access, analyze, manage, integrate, evaluate, and create information in a variety of forms using appropriate technology skills and communicate that information in an appropriate oral, written, or multimedia format. (p. 1)
>
> *Standard 2: Thinking and Reasoning Skills*—The student will demonstrate the ability to explore and develop new ideas, to intentionally apply sound reasoning processes and to frame, analyze and solve complex problems using appropriate technology tools. (p. 4)

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[1] More information about the Teacher Leadership Institute is available at http://wvde.state.wv.us/instruction/.

[2] More information about the BIE is available at http://www.bie.org/.

> *Standard 3: Personal and Workplace Skills*—The student will exhibit leadership, ethical behavior, respect for others; accept responsibility for personal actions considering the impact on others; take the initiative to plan and execute tasks; and interact productively as a member of a group. (p. 5)

Significant resources have supported the professional development effort to prepare teachers to use PBL as a method for teaching 21st century skills; consequently, the WVDE Office of Research (OR) and BIE, in collaboration with the WVDE Office of Instruction (OI) undertook a summative evaluation of the effect of PBL implementation on teachers' perceived ability to teach and assess 21st century skills, and on student achievement. A research proposal and research-funding request submitted to BIE in December 2010 was approved, and subsequently guided the research beginning in January 2011.

Review of Relevant Scholarship

Research suggests that PBL is not only aligned with 21st century skills, but also has a number of academic and other benefits. Many studies have reported positive changes in student motivation, attitude toward learning, critical thinking, and problem-solving skills resulting from their participation in project-based learning (Bartscher, Gould, & Nutter, 1995; Peck, Peck, Sentz, & Zasa, 1998; Tretten & Zachariou, 1995). Others have emphasized PBL as a form of rigorous content delivery, finding improved cognitive outcomes for students, but no similar gains in motivation and affective outcomes (Kanter & Konstantopoulos, 2010). The impact varies based on design and implementation approaches.

For most important outcomes (with the exception of short-term concept learning), PBL appears to be as effective as traditional instructional approaches, and there are studies that show PBL to be superior (Buck Institute for Education, 2009; Edutopia, 2001; Finkelstein, et al., 2010; Walker & Leary, 2008). The impact of PBL is most noticeable when assessments are designed to address performance on complex tasks, long-term retention, and deeper conceptual learning (Strobel & van Barneveld, 2008). Student work that involves an active mode of acquiring knowledge—authentic pedagogy—has been linked to heightened student achievement on standardized tests (Newmann & Associates, 1996; Newmann, Bryk, & Nagaoka, 2001) while studies from Detroit (Geier, et al., 2008) and in the United Kingdom (Boaler, 2002) indicate that carefully conducted PBL can improve achievement for diverse students.

As one of the authors of this study reported previously (Ravitz, 2010, p. 294), PBL-type instruction has been shown

- to increase understanding of concepts and the ability to apply knowledge as measured by standardized tests of subject matter (e.g., Finkelstein et al., 2010; Geier et al., 2008; Hickey, Kindfled, Horwitz, & Christie, 1999; Mergendoller, Maxwell, & Bellisimo, 2007; Walker & Leary, 2008);
- to enable students to remember what they have learned longer and use that knowledge in new situations (e.g., Dochy, Segers, Van den Bossche, & Gijbels, 2003; Schwartz & Martin, 2004; Strobel & van Barneveld, 2008);
- to enable students to learn how to work in groups, solve problems, and communicate what they have learned (e.g., Cognition and Technology Group at Vanderbilt, 1992; Gallagher, Stepien, & Rosenthal, 1992; Hmelo, 1998);

- to improve attitudes and motivation (e.g., Boaler, 2002); and
- to be especially effective with lower-achieving students (e.g., Finkelstein, et al., 2010; Geier et al., 2008; Hickey, Kindfled, Horwitz, & Christie, 1999; Lynch, Kuipers, Pyke, & Szesze, 2005; Newmann, Bryk, & Nagaoka, 2001).

Research Questions and Hypotheses

WVDE has emphasized PBL both for teaching of 21st century skills and for helping students learn core content at a deeper level (WVDE, n.d.). Our study tests the idea, articulated in Mergendoller, Markham, Ravitz, and Larmer (2006) that well-planned, managed, and assessed projects can help students develop 21st century skills at the same time they help students learn rigorous academic content.

We posed two central research questions in this study:

RQ1 Do teachers who received extended professional development and are experienced PBL users report that they teach 21st century skills more than other teachers?

RQ2 What do PBL-implementing teachers add to student achievement that is above and beyond the value added by traditional and incidental instruction received during a single school year?

To investigate these research questions, we proposed two study hypotheses:

H1 Teachers who received extended professional development and are experienced PBL users will report that they teach 21st century skills more than teachers who are not known to use PBL or who have received only limited professional development.

H2 Students of teachers who are considered to be experienced implementers of the BIE model of PBL will exhibit higher average test score gains when compared to students of teachers who did not use the BIE model of PBL.

With respect to H1, we reasoned that PBL and the practices it encompasses are designed, in part, to help students learn 21st century skills. For example, Shear, Novais, Means, Gallagher, and Langworthy (2010, p. 3) in their discussion of *deeper learning* and student-centered pedagogies discuss PBL-related practices that support learning of 21st century skills, including

> . . . models of teaching and learning that are project-based, collaborative, foster knowledge building, require self regulation and assessment, and are both personalized (allowing for student choice and relevance to the individual student) and individualized (allowing students to work at their own pace and according to their particular learning needs). Each of these elements has a strong base of prior research linking it to positive outcomes for students in terms of development of 21st-century skills (Bransford, Brown, & Cocking, 1999; Darling-Hammond et al., 2008).

While comparison group teachers might find ways to teach these skills using their own practices, teachers who went through TLI had an opportunity to learn about teaching these skills using PBL. It was hoped that this would help teachers be more effective and likely to teach and assess 21st century skills.

With respect to H2, we reasoned that proponents of PBL espouse using projects to motivate and enhance student learning and to help students to develop self-directed learning skills

that enable them to apply what they learn procedurally and conceptually in ways that are consistent with the requirements of the West Virginia 21st Century Content Standards and Objectives (WV CSOs)[3]. The items used on West Virginia's state summative assessment, the West Virginia Educational Standards Test 2 (WESTEST 2), are designed to assess standards using problems that involve multiple steps, requiring students to think critically and use information to solve a complex problem—which we reasoned is a set of skills similar to those students develop in PBL. Therefore, if PBL were to enhance learning and help students develop these essential 21st century skills, we posited that exposure to PBL may have the potential to impact performance on WESTEST 2; likewise, all other factors being equal, the absence of PBL may have a detrimental effect on student achievement.

[3] The WV CSOs were developed in 2006 by teams of master teachers and reviewed by internal and external stakeholders, including members of the Partnership for 21st Century Skills.

Methods and Results

West Virginia Department of Education (WVDE) Office of Research (OR) and Buck Institute for Education (BIE) staff completed the data collection and analysis stages in February 2012. Our methods varied by research question. Therefore, in this report we present the methodology and results separately for each question.

Research Question 1 Methods

The objective of RQ1 was to determine if teachers who learn about and implement the BIE model of project-based learning (PBL) indicate that they teach 21st century skills more than a comparable set of teachers who use their own set of instructional practices. Specifically, we tested the following hypothesis:

> Teachers who received extended professional development and are experienced PBL users will report that they teach 21st century skills more than teachers who are not known to use PBL or who have received only limited professional development.

Participant characteristics

For this research study, the treatment population was defined as the subset of West Virginia educators who had participated in weeklong PBL professional development sessions led by BIE and WVDE Office of Instruction (OI) staff during SY2008, SY2009, and/or SY2010 and who appeared to be using PBL to a significant extent[4].

Sampling procedures

BIE worked with the WVDE Office of Instruction (OI, the state program office that plans and provides the Teacher Leadership Institute PBL training) to identify experienced PBL-using teachers based on surveys conducted at the end of weeklong summer institutes during two consecutive summers. After considering data from more than 600 teacher attendees, 60 were identified who taught mathematics, social studies, science, or English/language arts in Grades 4-11, who had successfully published a project in the state's peer-reviewed project library, and whose surveys indicated at least a year of PBL experience and an intention to continue using PBL in their academic teaching. These teachers were identified as experienced PBL users because they had succeeded in publishing a project that met WVDE OI criteria and because based on their own self-identification they had used PBL for at least a year prior to the study and seemed committed to this way of teaching.

We focused on the instructional activities and perceptions of the TLI-trained teachers who used PBL during the spring semester of SY2011. As such, it was an important initial step of

[4] Throughout this document, the abbreviation "SY(20xx)" is used to denote the academic year under examination. In all cases, the year provided in text is the *ending* year for the academic year (e.g., SY2008 refers to the 2007–2008 academic year).

data cleaning for us to locate the identified PBL-using teachers in the SY2011 active list of teachers listed in the West Virginia Education Information System (WVEIS)[5]. In the process of locating these teachers in WVEIS, we encountered considerable attrition that had occurred between the TLI sessions from SY2008 to SY2010 and the beginning of the research project. This attrition may have resulted from a few teachers transitioning to nonteaching positions at the district or state level, transferring to other districts or schools, or otherwise dropping off the active teacher list or course schedule. An additional source of attrition resulted from a mismatch of participant names on our list of PBL-using teachers with the official WVEIS list of teachers—that is, our list included some nicknames that did not match full names (e.g., Pat vs. Patricia). As a result of these issues, several iterations were required for us to validate an accurate linkage between the list of PBL-using teachers and the official WVEIS roster. Fifty-seven teachers were validated to move forward in the study.

Once this subset of PBL-using teachers had been validated, a second step was to locate their course offerings in the SY2011 master course schedule. This step resulted in the elimination of several more teachers who (a) were absent from the course schedule, (b) were listed as being responsible for noninstructional or administrative course codes in the target semester, or (c) were listed with non-primary content area course titles (e.g., early childhood/elementary education). As a result of this step, we were left with a final list of 42 treatment group teachers who had been identified from the original list of PBL-using teachers.

Once we had identified our 42 treatment group teachers, we selected a comparison group by extracting from the SY2011 master course schedule all courses within the primary content areas and course codes matching those taught by treatment group teachers. From that list, we identified comparison group candidates using three additional criteria relative to the treatment group:

1. *They taught in the same school districts as PBL-using teachers*. This criterion was based on an assumption that students within the same districts would, to some extent, have similar school experiences based on local conditions, and that teachers within the same districts served under the same district-level priorities and policies.
2. *They taught at the same programmatic levels as PBL-using teachers*. Fourteen (33%) of the treatment group teachers taught at the elementary or middle school programmatic level and it was deemed important to match them with teachers at those levels. Note that since there were so few of these teachers, the elementary and middle school teachers were grouped together for purposes of this study.
3. *They had position codes in the teacher roster indicating they were a classroom teacher*. This criterion is somewhat self-explanatory as RQ1 was focused on classroom instructional practices.

This comparison yielded a shortlist of 187 potential matching candidates, of whom 42 were selected based on the nearest match relative to the PBL-using teachers' level of education and years of service.

[5] The WVEIS is the transactional data system used by West Virginia's county school systems for daily school information maintenance and warehousing of student data.

As a final step in the matching process, we cross checked the 42 comparison group teachers against another list provided by BIE of more than 200 individuals known to have participated in some degree of professional development related to PBL. We verified that none of the 42 comparison group teachers appeared on the list. This process resulted in a final sample of 84 teachers to complete surveys regarding their teaching of 21st century skills.

Sample power and precision

To enable us to show statistically significant differences between our treatment and comparison group teachers at the 95% confidence level, we calculated that we needed to obtain responses from 38 of the 42 teachers in each group.[6]

Measures and covariates

To measure and compare teacher practices and perceptions for RQ1, we developed the 21st Century Teaching and Learning Survey (see Appendix A, p. 41). This survey asked for teacher perceptions about their PBL use and teaching practices related to 21st century skills. It also asked for background information to help validate the list of PBL users and to identify their teaching responsibilities for RQ2.

We chose to conduct a survey study because we believed this to be the least intrusive method for collecting the needed data from a large group of geographically dispersed teachers. Use of an electronic survey system (SurveyMonkey) allowed us to distribute the surveys, follow up with nonrespondents, and collect data most efficiently.

Background variables

On the survey questionnaire, before they answered questions about their teaching practices, respondents were instructed to select a *target course*, and a *target class* in which they felt their practices—including PBL use if applicable—were most effective, and to answer the survey with this target class in mind. To address the question of differences in subject and grade taught, we used the target class information based on a roster of classes from WVEIS that were included with the survey instrument. We also asked background questions about teachers and their target class to verify how teachers were coded for the study and to allow us to more closely examine the findings.

As an indicator of *teacher leadership and professional development involvement* we asked teachers whether their work had included a significant focus on technology integration, formative and benchmark assessments, or project-based learning, the extent of their professional development overall (in hours), and whether they had helped lead professional development sessions in the past year. As an indicator of the *overall level of academic performance* in the target class, we asked teachers whether most of the students in this class were behind, at, or ahead of the expected achievement level for their grade. We also asked about teachers' assessment of student learning of academic content, the hours per week an average student might be expected to continue working on their assignments outside of class, and how much time stu-

[6] We used the MacCorr Research Solutions Online Sample Size Calculator to determine these numbers, available at http://www.macorr.com/sample-size-calculator.htm.

dents spent preparing for standardized tests. Finally, we asked about *block scheduling*, because this school structure variable is often considered favorable for PBL use.

Measuring 21st century skills

Our conceptualization of the skills came from the international Innovative Teaching and Learning study (Shear, Novais, Means, Gallagher, & Langworthy, 2010). We also considered the conceptualization of 21st century skills from The William and Flora Hewlett Foundation (2010). Appendix B, p. 59 shows the frameworks for these two respective organizations.

We selected or modified many survey items used to indicate that the skills were taught based on reliability data reported by Novais & Gallagher (2010) and personal communications with Gabriel Novais (April 27, 2011). We also reviewed items used in surveys in Chicago Public Schools (Consortium on Chicago School Research, 2005) and the draft documents from the The William and Flora Hewlett Foundation (2010). The WVDE OI reviewed the resulting framework (Figure 1) and instrument (Appendix A, p. 41) to make sure that items were compatible with the ideas put forth in West Virginia 21st Century Content Standards 1–3, described earlier (p. 1).

For an indication of rigorous content learning—which is an important component in all 21st century teaching and learning frameworks—we used questions that were independent from questions about the skills themselves. For our purposes content learning in the target class was indicated by test scores (RQ2) and by teacher perceptions of various student outcomes.

Figure 1. Definitions of 21st Century Skills

Code	Skill name and definition
CT	CRITICAL THINKING SKILLS refers to students being able to analyze complex problems, investigate questions for which there are no clear-cut answers, evaluate different points of view or sources of information, and draw appropriate conclusions based on evidence and reasoning.
CO	COLLABORATION SKILLS refers to students being able to work together to solve problems or answer questions, to work effectively and respectfully in teams to accomplish a common goal and to assume shared responsibility for completing a task.
CM	COMMUNICATION SKILLS refers to students being able to organize their thoughts, data, and findings; and share these effectively through a variety of media, as well as orally and in writing.
CR	CREATIVITY AND INNOVATION SKILLS refers to students being able to generate and refine solutions to complex problems or tasks based on synthesis, analysis, and then combining or presenting what they have learned in new and original ways.
S	SELF-DIRECTION SKILLS refers to students being able to take responsibility for their learning by identifying topics to pursue and processes for their own learning, and being able to review their own work and respond to feedback.
G	GLOBAL CONNECTIONS refers to students being able to understand global, geopolitical issues including awareness of geography, culture, language, history, and literature from other countries.
L	LOCAL CONNECTIONS refers to students being able to apply what they have learned to local contexts and community issues.
U	USING TECHNOLOGY AS A TOOL FOR LEARNING refers to students being able to manage their learning and produce products using appropriate information and communication technologies.

For each 21st century skill, the survey started by providing the definition (Figure 1), followed by a list of related practices—that is, student tasks teachers may have assigned as part of their repertoire for teaching each skill. The survey asked about the frequency of five to eight

such practices for each skill. For example, one of the practice items related to collaboration skills included, "In your teaching of your TARGET CLASS, how often have you asked students to work in pairs or small groups to complete a task together?" Response choices included 1, *Almost never*; 2, *A few times a semester*; 3, *1-3 times per month*; 4, *1-3 times per week*; 5, *Almost daily*.

After reading the definition of the skill and indicating the frequency of their practices, teachers indicated whether they had tried to teach these skills, whether students had learned, and if they had been able to assess these skills. Teachers responded to the following prompts substituting the name of the skill (e.g., critical thinking):

a. I have tried to develop students' _____ skills.

b. Most students have learned _____ skills while in my class.

c. I have been able to effectively assess students' _____ skills.

Response choices included 1, *Not really*; 2, *To a minor extent*; 3, *To a moderate extent*; 4, *To a great extent*, or 5, *To a very great extent*.

To summarize, we used a combination of teachers' practices in assigning different kinds of PBL tasks to students, and more general perceptions about how extensively they taught and assessed each of the 21st century skills. The resulting measures were used to construct indices, which allowed us to test the hypothesis (H1) that teachers who received professional development and are using PBL teach 21st century skills more than others.

Research design

Communications with study participants followed a process recommended by Dillman (2000), including multiple contacts and a social incentive of a $15 gift certificate to be awarded randomly to one out of every three respondents. We sent personal e-mail messages to teachers in the sample, requesting their participation and directing them to the online survey questionnaire via a hyperlink in the messages. We followed up with personal e-mails and faxes to schools.

Recoding participants

To validate that study participants had the expected participant characteristics the survey asked teachers whether PBL had been an emphasis for their teaching or professional development, the amount of professional development they had received, and the extent of their use of PBL during the prior year. We recoded PBL teachers who said they did not consider PBL to have been an emphasis, who had not used PBL for at least a year, or who had not received extended professional development in PBL. Out of the original 42 PBL teachers, we were only able to verify that 24 met our criteria during the study period (see Appendix C, p. 61 for recoding details).

Index construction

Prior to constructing our indices we analyzed both the reliability and factor structure for each of the measures. Both practice and perception measures were highly correlated within each skill, allowing them to be combined into an overall index for each skill with strong reliability (standardized alpha = .90 or greater, with inter-item correlations all above .58). The overall in-

dex for all items combined had alpha = .986. The items with the lowest communalities (corrected item total correlations) were items connected to *global connections*, *collaboration skill*, and *using technology as a tool for learning*.

Factor analyses helped verify that the instrument seemed to be measuring different constructs. All factor analyses used principal axis factoring extraction, with Varimax rotation and Kaiser normalization. In many cases, factor analysis seemed to confirm that separate constructs were being measured. For example, the last four skills— *self-direction*, *global connections*, *local connections*, and *using technology as a tool for learning*—emerged cleanly as four different factors (see Table A 2 in Appendix D, p. 63). However, *critical thinking*, *creativity and innovation*, *collaboration*, and *communication* items were less empirically distinct, often loading on their preconceived factors, but not always. For example, many of the items intended to measure *creativity and innovation*-related practices loaded with *critical thinking* items (see Table A 3, p. 65). The perception items for the first four measures, however, revealed a clean clustering of items (see Table A 4, p. 67). These factor analyses overall lend support to the presence of different constructs. Combined with the reliability runs these analyses suggest ways to reduce the number of measures and items needed in future studies.

Statistical tests and analyses

For each measure of 21st century skills we focused on the difference between teachers who used PBL with extended professional development (n = 24) and others who did not use PBL or had limited professional development (n = 38). We compared the mean scores and computed effect sizes based on the overall standard deviation. The comparison group included teachers from the original PBL and matching samples, who said they used PBL but did not have extended professional development. In one of our analyses we used this group as a third category (n = 17), with effect sizes based on a comparison to the remaining group who did not use PBL at all (n = 21). This was useful in illustrating that PBL-using teachers with limited professional development on average fell between those who did not use PBL at all and those who used PBL with extended professional development.

Statistical significance was calculated using independent samples t tests for comparisons of means between two different sets of teachers, and ANOVA tests for comparison of means across three or more groups. Chi-square tests were used to analyze the distribution of background variables (e.g., block scheduling) across PBL and non-PBL teachers. For continuous measures, with at least five or more clearly ordered choices, we used correlations to indicate whether these measures (e.g., the number of projects used) are related to the teaching of 21st century skills.

Research Question 1 Results

The survey opened on May 23, 2011 and closed on June 20, 2011. We received completed responses from 62 of 84 teachers for an overall response rate of 74%. We received surveys from 38 of 42 PBL-using teachers (90%) and 24 of 42 matched teachers (57%). These response rates were considered adequate for our purposes and we did not attempt to analyze nonrespondents.

We started by confirming that teachers in the PBL-using category more frequently reported extended professional development and class time devoted to extended assignments or

projects (Table A 5, p. 69 in Appendix E). We also checked to see if our measures of 21st century skills teaching were correlated to these indicators of PBL use (Table A 6, p. 70). The overall measure of 21st century skills teaching was positively correlated with time spent in professional development (r = .34, p < .01), the number of extended assignments (r = .47, p < .001), weeks conducting extended projects (r = .29, p < .05) , and overall class time devoted to extended projects (r = .35, p < .01).

Overall results

Table 1 addresses the hypothesis (H1) that teachers who used PBL and received extended professional development report significantly more teaching of 21st century skills. There were substantial and statistically significant effect size differences between teachers who used PBL with extended professional development and other teachers in the sample, whether we used a two-category comparison (i.e., comparing to all other teachers in the sample), or a three-category comparison (i.e., dividing the comparison groups into teachers who did not use PBL at all and those who indicated limited PBL use with limited professional development).

Table 1. Mean 21st Century Skills Index by PBL Use (Two and Three Categories)

PBL-use category	*n*	Mean 21st Century Skills Index (Z score)	*SD*	Effect size	*p* <
Total	62	.00	1.00		
Two categories					
No PBL or limited PD	38	-.35	.93	.91	*t* test .001
PBL use with extended PD	24	.56	.86		
Three categories					
No PBL emphasis or use	21	-.59	1.02	1.15	ANOVA .001
Used PBL with limited PD	17	-.05	.72		
PBL use with extended PD	24	.56	.86		

Statistical test data are available in Table A 7 (p. 71) for *t* tests and Table A 8 (p. 72) for ANOVA tests. Effect sizes for the three categories are based on means for the first and third categories only (i.e., *no PBL emphasis or use*, versus *PBL use with extended professional development*). Tukey post-hoc analyses (available from the author) suggested that this comparison was statistically significant (p < .001), while the other comparisons did not reach statistical significance.

These findings confirm H1 for the first research question by indicating that PBL use and extended professional development were clearly associated with more teaching of 21st century skills. In the following analyses we attempt to tease this relationship apart for the purpose of improving our understanding and clarifying how robust this relationship is across different skills, subjects taught, and teacher and classroom characteristics.

Results for 21st century skills: Frequency of PBL use

The results were remarkably consistent across the different 21st century skills (Table 2). The only major exception to the overall pattern was teaching of *global connection skills*. Subsequent analysis suggested this skill seemed to be more a function of whether a teacher taught social studies than whether they used PBL.

Table A 9 (p. 73) provides independent samples *t*-tests of statistical significance for the mean scores on the practice measures in Table 2. Table A 10 (p. 74) shows how teachers responded to the individual practice items by PBL group. Statistical significance tests for individual items are available from the author.

Table 2. Mean 21st Century Skills Practices for Each Skill by PBL Use

Practice Index Measures (N)	Total (*N* = 62)	No PBL or extended PD (*n* = 38)	PBL with extended PD (*n* = 24)	*SD*.	Effect size	*p* <
Overall	.00	-.35	.36	1.00	.71	.001
Critical thinking skills	.00	-.22	.35	.76	.76	.005
Collaboration skills	.00	-.32	.52	.84	1.00	.001
Communication skills	.00	-.33	.53	.81	1.06	.001
Creativity & innovation skills	.00	-.30	.48	.85	.93	.001
Self-direction skills	.00	-.21	.34	.81	.68	.01
Global connections skills	-.01	-.02	.01	.87	.03	.90 (*ns*)
Local connections skills	.00	-.25	.40	.87	.75	.005
Technology as a tool for learning skills	.00	-.27	.43	.81	.86	.001

Results for 21st century skills: Extensiveness of PBL use

In addition to reporting practices related to 21st century skills more frequently (Table 2), teachers in the PBL group also perceived themselves as having taught the skills to a greater extent than the comparison group. According to these teacher perceptions (Table 3) the 21st century skills that received the greatest amount of instruction were *collaboration* and *critical thinking*, while *global connections* and *local connections* received the least amount of instruction. Across the eight 21st century skills, teachers were most likely to report they had *tried to develop the skill*. They were second most likely to report that *most students had learned the skills* and least likely to report that they had been able to *effectively assess the skills*.

The remaining survey response analyses explore whether the relationships between PBL use and 21st century skills teaching varied according to the characteristics of the target class and the teachers. Target class characteristics include subject taught, teacher-reported learning outcomes, and achievement levels.

Table 3. Mean Perceptions of 21st Century Skills Taught by PBL Use

Perception Item Responses (Low N)	Total mean (*n* = 60)	Total *SD*	No PBL or limited PD (n = 37)	PBL with extended PD (n = 23)	Effect size	Independent samples *t* test, *p* <
Critical thinking skills						
I have tried to develop	4.19	.87	3.95	4.58	.73	.01
Most students have learned	3.58	.93	3.29	4.04	.81	.001
I have been able to effectively assess	3.35	.83	3.16	3.67	.61	.02
Collaboration skills						
I have tried to develop	4.03	.97	3.68	4.58	.92	.001
Most students have learned	3.77	1.06	3.37	4.42	.99	.001
I have been able to effectively assess	3.57	1.12	3.13	4.30	1.05	.001
Communication skills						
I have tried to develop	3.65	1.10	3.26	4.25	.89	.001
Most students have learned	3.29	1.11	2.89	3.92	.92	.001
I have been able to effectively assess	3.19	1.17	2.74	3.92	1.01	.001
Creativity and innovation skills						
I have tried to develop	3.48	1.10	3.13	4.04	.83	.001
Most students have learned	3.05	1.29	2.55	3.83	1.00	.001
I have been able to effectively assess	3.00	1.18	2.62	3.61	.84	.001
Self direction skills						
I have tried to develop	3.44	1.07	3.16	3.88	.67	.01
Most students have learned	2.89	1.04	2.55	3.42	.83	.001
I have been able to effectively assess	2.95	1.09	2.61	3.50	.82	.001
Making global connections skills						
I have tried to develop	2.74	1.20	2.81	2.63	-.16	*ns*
Most students have learned	2.52	1.24	2.55	2.46	-.08	*ns*
I have been able to effectively assess	2.31	1.14	2.37	2.21	-.14	*ns*
Making local connections skills						
I have tried to develop	2.65	1.13	2.32	3.17	.75	.01
Most students have learned	2.34	1.07	2.13	2.67	.50	.05
I have been able to effectively assess	2.26	1.03	2.08	2.57	.47	*ns* (.08)
Using technology as a tool						
I have tried to develop	3.42	1.15	3.08	3.96	.76	.01
Most students have learned	3.15	1.27	2.84	3.63	.62	.02
I have been able to effectively assess	3.03	1.23	2.79	3.42	.51	.05

Results within and across content areas

Starting with content area taught in the target class, findings suggest large effects for three of the four major content areas, and a moderate effect for social studies (Table 4). Because of the relatively small number of cases in each content area, however, the differences between PBL and other teachers was only statistically significant for mathematics teachers (*ES* = 1.21, *p* <

.002). Yet, the mean difference was substantial and approached statistical significance for science teachers (*ES* = .95, $p < .09$) and English teachers (*ES* = 1.06, $p < .06$). This finding did not hold for social studies teachers (*ES* = .47, ns).

Table 4. Mean 21st Century Skills Index by Subject and PBL Use

	Subject of target class	Total	No PBL or extended PD	PBL with extended PD	Effect size	*p* <
	Overall	0.00	-.35	.56	0.91	.001
	Mathematics	-.32	-.86	.52	1.21	.002
Mean	Science	-.06	-.34	.26	0.95	.09 (*ns*)
	Social Studies	.36	.21	.69	0.47	.45 (*ns*)
	English	.26	-.12	.87	1.06	.06 (*ns*)
	Overall	62	38	24		
	Mathematics	23	14	9		
N	Science	13	7	6		
	Social Studies	13	9	4		
	English	13	8	5		
	Overall	1.00	.93	.86		
	Mathematics	1.14	.81	1.10		
SD	Science	.64	.62	.54		
	Social Studies	1.00	1.13	.65		
	English	.94	.74	.95		

*** $p < .001$, ** $p < .01$, * $p < .05$ See Table A 11 in Appendix E (p. 77) for statistical significance analyses.

There were variations across content areas in how much the different skills were taught. Table A 12 (p. 77) shows the overall index score (for frequency and extensiveness combined) of each skill by subject area. Mathematics teachers on average reported teaching the 21st century skill practices least frequently, while science teachers reported above average use of practices specifically related to *collaboration* and *communication skills*. English and social studies teachers reported the most frequent use of the practices overall, with a large portion of the social studies effect coming from *global connections*, the only skill for which there was a statistically significant difference across the four content areas (Table A 13, p. 77).

Results by perceived student workload, outcomes, and achievement levels

Other characteristics of the target class we examined included teacher perceptions about how much students learned or were motivated by the class, how much time they spent on class work outside of class, and how much time they spent preparing for standardized tests.

Compared to other teachers, PBL-using teachers with extensive professional development (hereafter, *PBL-using teachers*) more frequently indicated that students learned what they needed to do well on standardized tests (*ES* = .55, $p < .05$), could apply or transfer what they learned to new tasks and situations (*ES* = .66, $p < .01$), and were motivated to learn more about the subjects they studied (*ES* = .55, $p < .05$). There were no statistically significant differences in whether what students learned was personally relevant (*ES* = .28, $p < .28$, *ns*), the amount of time teachers estimated students spent working on class work outside of class (*ES* = -.27, $p < .31$, *ns*), or preparing to take standardized tests (*ES* = -.16, $p < .55$, *ns*). See Table A 5 (p. 69) for means comparisons and Table A 7 (p. 71) for statistical tests. Taken together, these results sug-

gest PBL-using teachers believe as much if not more than comparison teachers that their students were working just as hard, were prepared just as well, and learned as much as students of other teachers in the sample.

Regarding the class academic performance level as a whole, it appears that teaching of 21st century skills was fairly evenly distributed regardless of teachers' ratings of the overall student academic performance level. If anything, responses suggest that classes with students *at the expected level* had the least opportunity to learn these skills (Table 5).

Table 5. Mean 21st Century Skills Index by Class Academic Performance and PBL Use

		Total	No PBL or extended PD	PBL with extended PD	Effect size	*p* <
Mean	Total	0.00	-.38	.56		
	Behind most students	.23	-.38	.95	1.30	.01
	At the expected level	-.30	-.72	.43	1.10	.006
	Ahead of most students	.20	.04	.43	.42	.34 (*ns*)
N	Total	60	36	24		
	Behind most students	13	7	6		
	At the expected level	25	16	9		
	Ahead of most students	22	13	9		
SD	Total	1.02	.95	.86		
	Behind most students	1.02	.71	.87		
	At the expected level	1.05	.96	.80		
	Ahead of most students	.93	.93	.93		

There was no statistically significant difference in distribution of perceived student achievement levels between PBL groups, as indicated by the chi-square tests shown in Table A 14(p. 78; $N = 60$, $X^2 = 2.451$, $df = 4$, $p < .65$) and teacher ratings of the class performance level was not by itself a significant predictor of having taught 21st century skills (ANOVA $p < .15$, *ns*). However, after splitting the file by teacher-reported achievement levels, PBL-using teachers reported more teaching of 21st century skills overall, with statistically significant differences for classes identified as being behind most students ($ES = 1.30$, $p < .01$) and at the expected achievement level ($ES = 1.10$, $p < .005$). These results are shown in Table 5 (above) with a graphic representation in Figure 2 (p. 17) and details of the statistical significance tests in Table A 8 (p. 72).

In summary, the distribution of achievement levels reported by teachers in the PBL-using and comparison groups were not significantly different. While the PBL-using and non-PBL teachers did not report significantly different student populations, they did report significantly different teaching practices and perceptions for classes that were behind and at the expected level of academic performance.

Results by block scheduling

We asked about whether the target class used a block schedule, which may make it easier to carry out projects. Table 6 and chi-square tests (Table A 14, p. 78) show no significant differ-

ence in presence of block scheduling across PBL users and nonusers (N = 62, X^2 = 3.352, df = 4, p < .50). By itself, block scheduling was related to 21st century skills measures to an extent that approached statistical significance (ANOVA p < .10).

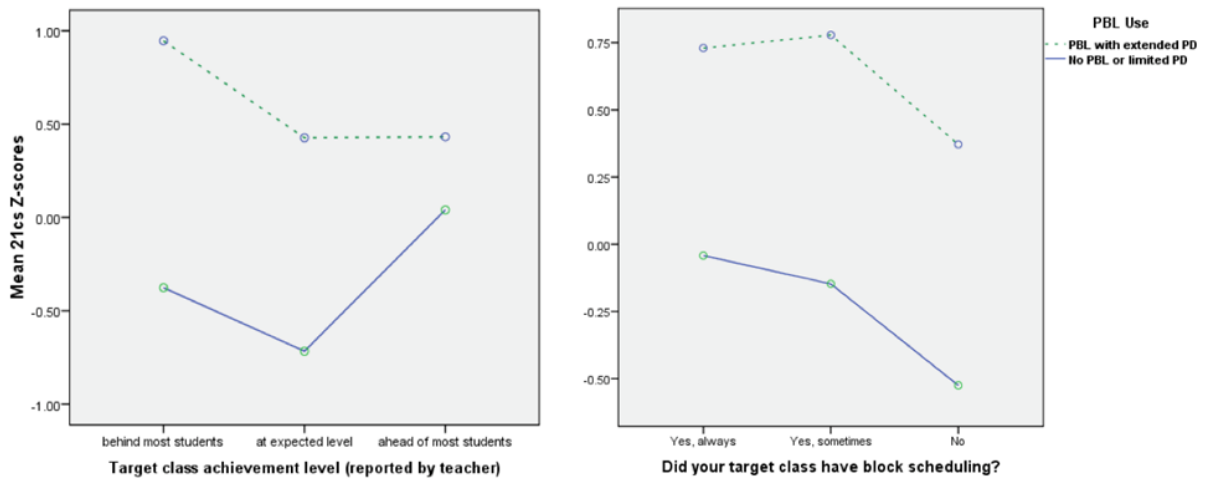
Table 6. Mean 21st Century Skills Index by Block Schedule and PBL Use

	Subject of target class	Total Mean	No PBL or extended PD	PBL with extended PD	Effect Size	*p* <
Mean	Total	.00	-.35	.56		
	Always block	.27	-.04	.73	.69	.13 (*ns*)
	Sometimes block	.47	-.15	.78	1.58	.05
	No block	--.23	-.53	.37	.96	.005
N	Total	62	38	24		
	Always block	20	12	8		
	Sometimes block	6	2	4		
	No block	36	24	12		
SD	Total	1.00	.93	.86		
	Always block	1.12	1.19	.87		
	Sometimes block	.59	.24	.43		
	No block	.94	.78	.97		

After splitting the file by block schedule categories, PBL-using teachers reported more teaching of 21st century skills, with statistically significant differences for teachers who reported no block schedule (*ES* = .96, p < .005) and sometimes having a block schedule (*ES* = 1.58, p < .05). For teachers reporting they always had a block schedule, there was not a statistically significant difference between PBL-using and non-PBL teachers (*ES* = .69, p < .13, *ns*), but there was a modest difference. These results are shown in Table 6 with a graphic representation in Figure 2 and details of the statistical significance tests in Table A 8 (p. 72)**.**

In Figure 2, the top line represents PBL-using teachers, while the bottom line represents mean scores for non-PBL teachers. The horizontal axis shows the categories for class achievement and block scheduling, respectively. Taken together these findings suggest that the relationship between 21st century skills teaching and PBL use is largely independent of class achievement reported by the teacher, and block scheduling.

Figure 2. Mean 21st Century Skills Index by PBL Use, Within Class Achievement and Block Schedule



Results by teacher background

Finally, we examined differences in the proportion of teachers who indicated that they had helped lead a professional development session for others since 2008. Our analysis indicates that 100% of the PBL-using teachers in our study had helped provide professional development to others, compared to 37% (14 out of 38) of the comparison group (Table 7). Unlike the other background variables this difference in distribution was statistically significant (chi-square $p < .001$, Table A 14, p. 78). Moreover, based on independent samples *t* tests (Table A 7, p. 71) having led professional development by itself was a significant predictor of 21st century skills teaching ($ES = .77$, $p < .01$).

Table 7. Mean 21st Century Skills Index by Teacher as PD Leader and PBL Use

	Helped lead any PD sessions?	Total	No PBL or limited PD	PBL with extended PD	Effect Size	*p* <
	Total	.00	-.35	.56		
Mean	No	-.47	-.47	--	--	--
	Yes	.30	-.15	.56	.83	.01
	Total	62	38	24		
N	No	24	24	0		
	Yes	38	14	24		
	Total	1.00	.93	.86		
SD	No	1.06	1.06	--		
	Yes	.85	.63	.86		

Of the various background and contextual measures, this indicator of teacher background is the most noteworthy because there were not only significant differences in mean responses, but there were significant differences in population distribution. This suggests that professional development could have a significant impact on the overall results. However, when we control for this teacher background variable—focusing only on the group that had led professional development by using split-file analyses (Table 7 above and Table A 7, p. 71)—we still see

evidence that PBL use was related to significantly higher mean 21st century skill scores (*ES* = .83, $p < .01$).

Research Question 2 Methods

To address RQ2, we devised methods for investigating the following hypothesis:

> Students of teachers who are considered to be strong implementers of the BIE model of PBL will exhibit higher average test score gains when compared to students of teachers who are not known to use BIE's model for PBL.

The null hypothesis postulates that there will be no difference between these two groups of students.

Participant characteristics

The treatment population for RQ2 consisted of all *students* who participated in courses offered by a subset of WV public school teachers, all of whom indicated via a survey administered in the spring of the 2010–2011 school year that their level of PBL use was extensive in core content areas (SY2011; see RQ1). As described earlier, the survey asked all responding teachers to select a target course in which they had implemented at least some components of PBL during SY2011. Then they were asked to indicate their level of PBL use in that target course. We ultimately coded teachers into one of three levels of PBL use based upon their survey responses (1 = *no PBL use*, 2 = *limited PBL use*, and 3 = *extensive PBL use*). Respondents who indicated a valid target course in one of four core content areas (i.e., mathematics, English/language arts, science, or social studies) and who also reported extensive PBL use in this course were subsequently identified as the teachers of treatment group students. Student-level data were collected for these target courses and a comparison group was selected using propensity score matching models (PSM) for subsequent analyses. Details of how these students were identified follow.

A total of 38 of the 42 PBL teachers identified as part of RQ1 responded to the spring SY2011 survey (90%). Almost all (97%) indicated a valid core content area target course. The breakdown of PBL implementation in those target courses is shown in Table 8.

Table 8. Number of Survey Respondents by PBL Implementation Status

Self-reported level of PBL use	Number of respondents	Percentage of sample
TOTAL	38	100
1 (no PBL use)	9	24
2 (limited PBL use)	5	13
3 (extensive PBL use)	24	63

Of the 24 teachers who reported extensive PBL use, we were able to verify via course scheduling rosters retained by the WVDE that 17 survey respondents self-reported implementing PBL in a target course that was offered during SY2011 (71%). These teachers are hereafter referred to as *PBL teachers* and were identified as those teachers from whose courses students were selected. The breakdown of PBL teachers by content area is shown in Table 9.

Table 9. Number of WVEIS Validated PBL Teachers by Content Area

Content area	Number of teachers	Percent of sample*
Total	17	100
Mathematics	5	29
English/language arts	5	29
Science	4	23
Social studies	3	18

*Percentages do not add up to 100 due to rounding.

We next collected unique student identifiers for all those students who were actively enrolled in the target courses offered by PBL teachers (hereafter referred to as the *PBL group*). We excluded students in Grades 3 and 12 because we required two points of assessment data to answer RQ2.[7] A total of 821 unduplicated students were identified within all offered sections of the target courses reported by PBL teachers. The breakdown of students by content area is shown in Table 10.

Table 10. Number of Students in PBL Courses by Content Area

Content area	Number of students	Percentage of sample
Total	821	100
Mathematics	112	14
English/language arts	222	27
Science	298	36
Social studies	189	23

Sampling procedures

Having identified the 821 students in the PBL group, we next sought to identify a suitable comparison group (hereafter referred to as the *non-PBL group*). We used propensity score matching (PSM) to derive four samples of students (i.e., one per content area) that were inclusive of PBL group students and an equal number of matched non-PBL group students.

For the PSM analyses, we first created a binary indicator for each student that indicated whether or not the student was a member of the PBL group. We then operationalized our propensity score as the conditional probability of being assigned to the PBL group given a vector of observed covariates upon which we sought to exercise control because of their possible influence on student achievement. In this study, the covariates we used were (a) school district, (b) grade, (c) race, (d) sex, (e) free and reduced-price lunch eligibility, (f) special education eligibility, and (g) prior academic achievement (i.e., *z* score for SY2010 in the relevant content area). Thus, the propensity score was the predicted probability of being assigned to the PBL group, obtained from a binary logistic regression of an indicator of being enrolled in a course where PBL was implemented on the listed covariates (Rosenbaum & Rubin, 1983). We used the nearest neighbor method in SPSS and specified a delta or difference ranging from .02 to .04 in our models, based on the standard error of each model, meaning the predicted probability of a non-PBL student

[7] Grade 3 is the first year of state summative testing and grade 12 students are not currently tested in West Virginia.

could only vary from .02 to .04 compared to that of the PBL student to whom they are matched. We ran the procedure separately for each observed course code to ensure all potential matches took the same course as their PBL counterparts during SY2011.

Notably, the PSM analyses did not function properly for Course Code 3044 (conceptual mathematics). We excluded students in course 3044 because two variables (grade and special education eligibility) in the logistic regression model had very large coefficients and resulted in nonoverlapping propensity scores between the PBL and non-PBL groups. In general, variables with large coefficient values in a logistic regression model indicate either that the variable is extremely effective (should probably be removed from the model and used as an external rule or filter) or that the variable contains biased data and is highly correlated to the explained variable. The latter (bias) was probably the case in our model; therefore, we removed these students.

Finally, we also conducted a series of analyses to verify the PSM process was successful. First, we conducted a series of chi-square tests to determine if the PBL group and the matched non-PBL group differed on the categorical covariates entered into the logistic regression (school district, grade, race, sex, free and reduced-price lunch eligibility, and special education eligibility). We conducted these analyses by content area. We then utilized independent samples *t* tests to determine if the two groups differed on the interval level covariate entered into the logistic regression (i.e., SY2010 achievement). In both sets of analyses, we presumed that violation of the null hypothesis would provide evidence that our groups may not be adequately matched. These tests were conducted prior to the final analyses.

Sample size, power, and precision

Our intent for all analyses was to have sufficient statistical power to examine differences in achievement between the two groups for each content area under examination (i.e., mathematics, English/language arts, science, and social studies). Ultimately, the power for our analyses, which is based on the observed effect size for the differences, ranged from very low in social studies where we observed a very small effect size (.12 or 12%) to moderate in science (.77 or 77%). The power for our aggregated analyses was much higher (i.e., .90 or 90%), but did not approach the criterion of 95% confidence. More details about sample size and power for these analyses are in the results section.

Measures and covariates

The main outcome measure for RQ2 was the gain in standard deviation units between students' standardized WESTEST 2 scores as measured at the conclusion of SY2010 and SY2011. We created the gain score variable via a multistep process. First, we computed *z* scores for each student using the population of all students in the state as the referent group. We standardized each student's WESTEST 2 scale scores within each grade level band (i.e., Grades 3, 4, 5, etc.). This was done to ensure that each *z* score accurately represented the student's relative position within the distribution of performance for her/his grade-level peers. We completed the process using the SY2010 and SY2011 datasets independently. We then computed an SY2010 to SY2011 gain score for each student by subtracting the student's SY2010 *z* score from her/his SY2011 *z* score. The resulting gain scores represent the magnitude and direction of each student's change in position with her/his grade level peers, as measured in standard deviation units. Gain scores were computed for each of the four core content areas assessed by WESTEST 2. We then exam-

ined the differences in the average gain scores for PBL and non-PBL groups in our main analysis.

As indicated above, we used a variety of covariates in our main analysis to control for their potential impact on the outcome measure. The covariates included in each PSM model were (a) school district, (b) grade, (c) race, (d) sex, (e) free and reduced-price lunch eligibility, (f) special education eligibility, and (g) prior academic achievement (i.e., *z* score for SY2010 in the relevant content area). In addition, we held constant the variability in each student's core content area course enrollment by conducting each PSM model within a single course code. For example, if a student in the PBL group experienced PBL in an Algebra 1 course, we ran the PSM algorithm within the pool of all other non-PBL Algebra 1 students, and selected the nearest neighbor based upon the vector of covariates noted above.

Research design

Following the PSM analysis, we conducted a set of independent samples *t* tests to determine if the PBL and non-PBL groups of students differed significantly in terms of the average achievement gains experienced during SY2011. Each analysis used group membership (PBL or non-PBL) as the independent variable and gain score in terms of standard deviation units between SY2010 and SY2011 as the dependent variable. These analyses were initially conducted independently within each content area (i.e., mathematics, English/language arts, science, and social studies), and then, to increase statistical power, conducted in aggregate (i.e., with the four content areas treated as one).

Research Question 2 Results

As noted previously, we began our investigation of RQ2 by confirming that the PSM model had resulted in adequately matched groups. We believed this was essential prior to conducting the main analysis. We initially used chi-square test statistics to examine this assumption for all six of the categorical covariates. We found that the chi-square values were not significant for any covariate or content area except in the case of race for English/language arts and school district, which differed significantly for all four content areas.

In the cases where our assumptions were violated, we conducted follow-up analyses in the form of factorial analysis of variance (ANOVA). Each analysis used group membership and the categorical covariate in question as predictors of the relevant gain score, which would serve as the dependent variable in our main analyses. We presumed that the presence of an interaction effect between group and the covariate of interest would represent a potential bias. If no interaction effects were present, we accepted the matching as successful and proceeded to main analyses.

Table 11 illustrates the chi-square statistics and associated *p* values for each covariate. For those *covariate*group combinations* where the chi-square statistic was significant, we also present the significance value (*p*) for the interaction effect between *group* and the covariate of interest upon the relevant gain score[8]. Notably, none of the *p* values for such interaction effects

[8] Complete statistics for the factorial ANOVAs can be found in Appendix F, p. 77.

were statistically significant, leading us to conclude that matching was successful on all covariates.

Table 11. Verification of Matching for Categorical Covariates

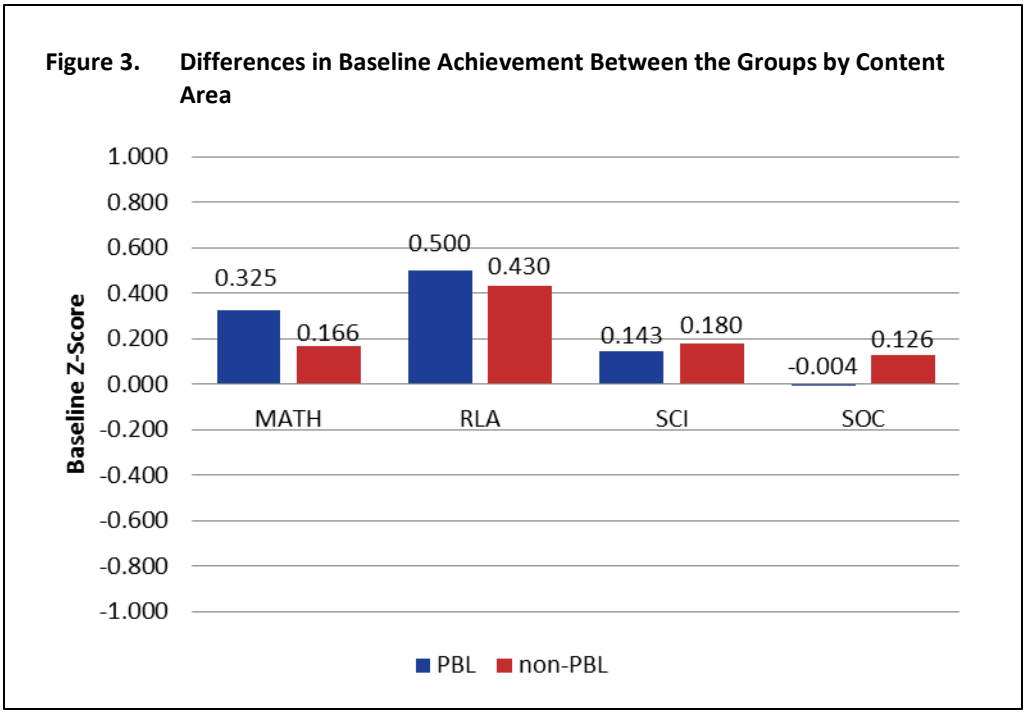
Covariate	X^2	*df*	*p*	Assumption	*p* (interaction effect)	Conclusion
Mathematics						
School district	52.477	14	.000	Violated	.548	OK
Grade	1.026	4	.906	Met	N/A	OK
Race	1.382	3	.710	Met	N/A	OK
Free and reduced-price lunch eligibility	.288	1	.591	Met	N/A	OK
Special education eligibility	.806	1	.369	Met	N/A	OK
Sex	1.473	1	.225	Met	N/A	OK
English/language arts						
School district	306.487	18	.000	Violated	.856	OK
Grade	.337	3	.953	Met	N/A	OK
Race	10.081	3	.018	Violated	.765	OK
Free and reduced-price lunch eligibility	.009	1	.923	Met	N/A	OK
Special education eligibility	.450	1	.502	Met	N/A	OK
Sex	1.777	1	.182	Met	N/A	OK
Science						
School district	53.145	12	.000	Violated	.502	OK
Grade	2.014	3	.570	Met	N/A	OK
Race	2.068	4	.723	Met	N/A	OK
Free and reduced-price lunch eligibility	.062	1	.803	Met	N/A	OK
Special education eligibility	1.362	1	.243	Met	N/A	OK
Sex	.242	1	.622	Met	N/A	OK
Social studies						
School district	164.565	17	.000	Violated	.551	OK
Grade	2.016	3	.569	Met	N/A	OK
Race	5.122	4	.275	Met	N/A	OK
Free and reduced-price lunch eligibility	1.524	1	.217	Met	N/A	OK
Special education eligibility	1.965	1	.161	Met	N/A	OK
Sex	.266	1	.606	Met	N/A	OK

Each PSM model included one interval level covariate as well for which chi-square analyses were not appropriate (prior academic achievement). Again, for this covariate we presumed a lack of statistically significant differences among the groups to represent evidence of a successful matching process. We conducted a set of four independent samples *t* tests to test this assumption. Significance values for each *t* test indicated that the groups did not differ significantly on baseline academic achievement; *thus, we concluded that for no content area did one group have a significantly different starting point*. Table 12 presents a summary of the results of the *t* tests and Figure 3 provides a graphical representation of the differences in baseline achievement between the groups by content area.

Table 12. Verification of Matching for Interval Level Covariate

	PBL		Non-PBL						
Content Area	*Z* score	*SD*	*Z* score	*SD*	*t*	*df*	*p*	Mean Δ	*SE* Δ
Mathematics	.325	1.05	.166	1.03	1.14	222	.254	.160	.139
English/Language Arts	.500	.760	.430	.976	.850	417.07	.396	.071	.083
Science	.143	.892	.180	.910	-.494	594	.621	-.036	.074
Social Studies	-.004	.932	.126	.945	-1.35	376	.178	-.130	.096

Figure 3. Differences in Baseline Achievement Between the Groups by Content Area



In conclusion, for all covariates in all content areas we believe the groups to have been adequately matched. In fact, the data indicated to us that the PSM analyses were remarkably successful in providing a matched group on the covariates of interest with the exception of school district. Our additional analyses indicated that this difference is likely of little concern to our examination because, while district is sometimes related to students' gain scores when examined independently, there were no statistically significant interaction effects between district and group—indicating that the potential influence of school district upon gain score is not differentially present among our groups. Taken together, *these results allow us to be confident that our groups are reasonably equivalent on all measured covariates.* As such, we proceeded to the main analysis within each content area.

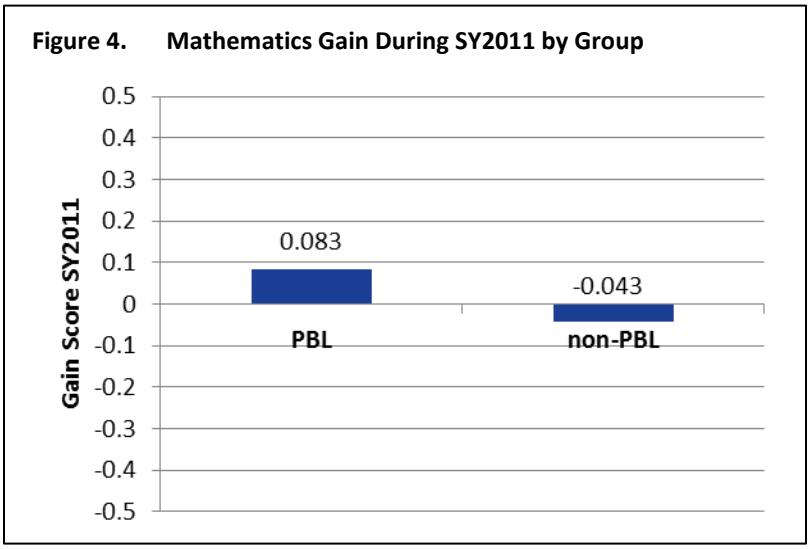
Mathematics main analysis

There were 112 students in the PBL group whose teachers indicated they implemented project-based learning in their mathematics courses during SY2011. This figure excludes those students who were enrolled in "conceptual math." As we note above, the PSM model did not function properly for this group. We used PSM to draw a matched sample of 112 students who took the same courses but whose teachers, according to BIE's records, had not participated in PBL professional development. Table 13 presents a description of the courses represented in the data and the number of students enrolled in those courses by group.

Table 13. Distribution of Students by Mathematics Course Code and Group

Course code	Course description	*n* PBL group	*n* non-PBL group
3004	Mathematics 4	23	23
3005	Mathematics 5	23	23
3006	Mathematics 6	46	46
3007	Mathematics 7	20	20

Figure 4. Mathematics Gain During SY2011 by Group



We conducted an independent samples *t* test to determine if the average gain score for PBL group students differed significantly from non-PBL students. The *t* test indicated no significant difference in mathematics achievement gains for PBL and non-PBL students during SY2011 ($t[222] = -1.294$; $p = .20$). The sample means are displayed in Figure 4, which illustrates a slightly higher average gain score for the PBL group (.083) when compared with the non-PBL group (-.043). However, as noted previously, this difference was not statistically significant.

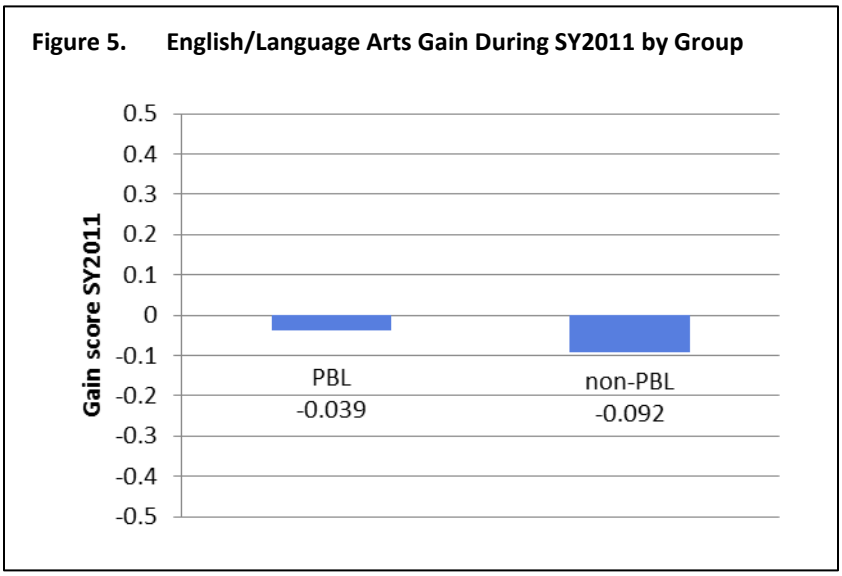
English/Language Arts main analysis

There were 222 students in the PBL group whose teachers indicated they implemented project-based learning in their English/language arts courses during SY2011. We used PSM to draw a matched sample of 222 students who took the same courses but whose teachers, according to BIE's records, had not participated in PBL professional development. Table 14 presents a list of the courses represented in the data and the number of students enrolled in those courses by group.

Table 14. Distribution of Students by English/Language Arts Course Code and Group

Course code	Course description	*n* PBL group	*n* non-PBL group
4005	English/language arts 5	25	25
4006	English/language arts 6	54	54
4010	English/language arts 10	143	143

Figure 5. English/Language Arts Gain During SY2011 by Group



We conducted an independent samples *t* test to determine if the average gain score for PBL group students differed significantly from non-PBL students. The *t* test indicated no significant difference in English/language arts achievement gains for PBL and non-PBL students during SY2011 ($t[442] = -.866$; $p = .39$). The sample means are displayed in Figure 5, which illustrates a slightly higher average gain score for the PBL group (-.039) when compared with the non-PBL group (-.092). However, as noted previously, this difference was not statistically significant.

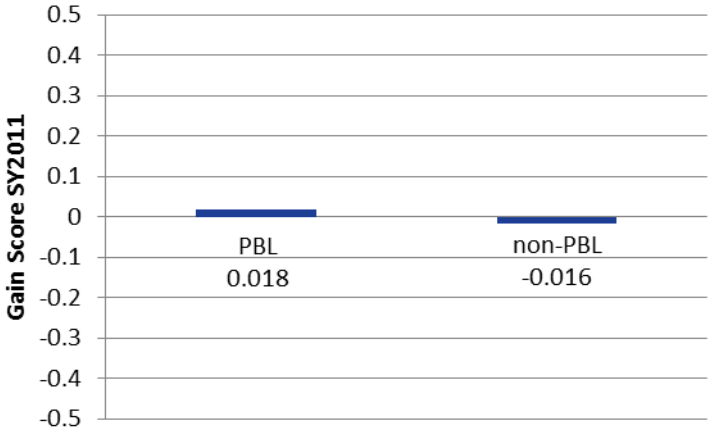
Science main analysis

There were 298 students in the PBL group whose teachers indicated they implemented project-based learning in their science courses during SY2011. We used PSM to draw a matched sample of 298 students who took the same courses but whose teachers, according to BIE's records, had not participated in PBL professional development. Table 15 presents a description of the courses represented in the data and the number of students enrolled in those courses by group.

Table 15. Distribution of Students by Science Course Code and Group

Course code	Course description	*n* PBL group	*n* non-PBL group
6005	Science 5th grade	67	67
6008	Science 8th grade	83	83
6021	Biology	148	148

Figure 6. Science Gain During SY2011 by Group



We conducted an independent samples *t* test to determine if the average gain score for PBL group students differed significantly from non-PBL students. The *t* test indicated no significant difference in science achievement gains for PBL and non-PBL students during SY2011 ($t[594] = -.523$; $p = .60$). The sample means are displayed

in Figure 6, which illustrates a slightly higher average gain score for the PBL group (.018) when compared with the non-PBL group (-.016). However, as noted previously, this difference was not statistically significant.

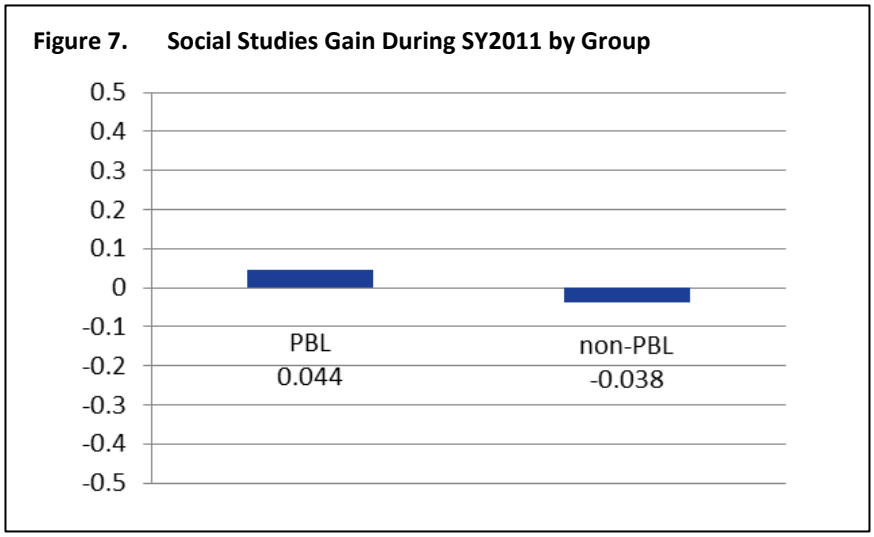
Social studies main analysis

There were 189 students in the PBL group whose teachers indicated they implemented project-based learning in their social studies courses during SY2011. We used PSM to draw a matched sample of 189 students who took the same courses but whose teachers, according to BIE's records, had not participated in PBL professional development. Table 16 presents a description of the courses represented in the data and the number of students enrolled in those courses by group.

Table 16. Distribution of Students by Social Studies Course Code and Group

Course code	Course description	*n* PBL group	*n* non-PBL group
7008	Social studies 8 – WV studies	66	66
7010	World history to 1900	123	123

Figure 7. Social Studies Gain During SY2011 by Group



We conducted an independent samples *t* test to determine if the average gain score for PBL group students differed significantly from non-PBL students. The *t* test indicated no significant difference in social studies achievement gains for PBL and non-PBL students during SY2011 ($t[376] = -1.077$; $p = .28$). The sample means are displayed in Figure 7, which illustrates a slightly higher average gain score for the PBL group (.044) when compared with the non-PBL group (-.038). However, as noted previously, this difference was not statistically significant.

Post-hoc analyses for RQ2

We conducted a series of additional post-hoc analyses for RQ2 to address three remaining areas of concern following the final analysis:

1. estimating observed power for each content area test;
2. determining if the inequality in starting points between groups negatively impacted potential growth for one group more than the other; and
3. determining the presence/absence of an effect for PBL when all four content areas were aggregated together to increase statistical power.

Power analyses

We calculated observed effect sizes (Cohen's *d*) for each of the original content area analyses. We then used a freely available power calculator (G*Power 3.1.2: Faul, Erdfelder, & Buchner, 2007) to determine the observed statistical power given the effect size and the sample size for each analysis. Our observed power ranged from very low in social studies where we observed a very small effect with a sample of less than 400 students (i.e., 0.12 or 12%) to moderate in science where we observed a small effect in a sample of nearly 600 students (i.e., 0.77 or 77%). For all analyses, we next used the power calculator to determine the sample size necessary to have 95% confidence in an effect the size of those observed in our study. Finally, we determined the number of additional cases necessary to achieve that level of confidence. The results appear in Table 17.

Table 17. Power Analyses for Content Area *T* Tests

Content Area	Observed effect (Cohen's *d*)	Sample size	Observed power	Necessary sample size for 95% confidence in observed effect	Additional cases needed for 95% confidence in observed effect
Mathematics	-.17 (small)	224	.73 (73%)	439	215
English/Language Arts	-.08 (very small)	444	.39 (39%)	2,020	1,576
Science	-.11 (small)	596	.77 (77%)	1,063	467
Social Studies	-.04 (very small)	378	.12 (12%)	8,111	7,733

Impact of nonequivalent starting points

As noted previously, we included prior academic achievement in the PSM models used for this study and we did not find statistically significant differences in baseline academic achievement when conducting analyses to verify that the PSM models had functioned properly. Nevertheless, we were still concerned that the small differences in baseline achievement between the PBL and non-PBL groups could have negatively influenced the ability of one group to exhibit change over time. As such, we conducted post-hoc analyses to verify that, regardless of starting point, on average, students in both groups had the same opportunities to achieve gains over time.

For each content area, we created a *binned* variable which indicated each student's starting quartile of baseline achievement. Quartile 1 represented the 1st to 24th percentile of baseline achievement, Quartile 2 represented the 25th to 49th percentile, Quartile 3 represented the 50th to 74th percentile, and Quartile 4 represented the 75th to 99th percentile.

We then constructed a series of linear models to test whether gain scores differed significantly based on starting points. First we entered starting point into a univariate model as the only predictor of student gain scores. The model was significant, indicating the presence of a potential bias based on starting point, whereby students who started in the bottom quartile had significantly higher gain scores than those who started in quartiles 2, 3, or 4 regardless of group membership (PBL versus non-PBL).

This main effect alone was not unexpected. However, to determine if this effect was present when group membership was accounted for (PBL or non-PBL), we ran a set of factorial

ANOVAs, entering group and baseline quartile of achievement into the model to predict gain scores. Our hypothesis was that the presence of a significant interaction effect in these models would be a red flag, indicating that starting points might be impacting gain scores in one group more than the other.

The factorial ANOVAs indicated that, for all content areas, there was a main effect for starting point, but the interaction between group and starting point was not statistically significant for any of the four content areas (see Table 18 through Table 21). As such, we concluded that, while there is an effect for starting point on students' academic gain score, the effect was not differentially present in our two groups. Therefore, it was not of critical concern in our main analyses. In other words, as we had anticipated, students' baseline achievement has an influence on their ability to demonstrate growth. Therefore, our efforts to include starting points in the PSM model were justified. Further, the results of the factorial ANOVAs, which indicated no interaction effects for group and starting point, provide satisfactory evidence that we effectively accounted for the influence of baseline achievement in this study.

Table 18. Tests of Between Subjects Effects for Factorial ANOVA Testing Interaction Between Group and Starting Point (Mathematics)

Source	Type III sum of squares	*df*	Mean square	*F*	*p*
Group	.767	1	.767	1.551	.214
Starting point	8.877	3	2.959	5.986	.001
Group*Starting point	1.025	3	.691	.691	.558
Error	106.773	216	.494	N/A	N/A

Table 19. Tests of Between Subjects Effects for Factorial ANOVA Testing Interaction Between Group and Starting Point (English/Language Arts)

Source	Type III sum of squares	*df*	Mean square	*F*	*p*
Group	.144	1	.144	.350	.554
Starting point	3.939	3	1.313	3.188	.024
Group*Starting point	.549	3	.183	.444	.722
Error	179.560	436	.412	N/A	N/A

Table 20. Tests of Between Subjects Effects for Factorial ANOVA Testing Interaction Between Group and Starting Point (Science)

Source	Type III sum of squares	*df*	Mean square	*F*	*p*
Group	.246	1	.246	.415	.520
Starting point	28.785	3	9.595	16.211	.000
Group*Starting point	.674	3	.225	.380	.768
Error	348.023	588	.592	N/A	N/A

Table 21. Tests of Between Subjects Effects for Factorial ANOVA Testing Interaction Between Group and Starting Point (Social Studies)

Source	Type III sum of squares	*df*	Mean square	*F*	*p*
Group	.950	1	.950	.528	.161
Starting point	27.348	3	9.116	1.968	.000
Group*Starting point	.909	3	.303	18.884	.597
Error	178.619	370	.483	.628	N/A

Aggregating content areas to increase statistical power

As indicated above, the observed statistical power for our individual content area analyses was well below the criterion of 95% confidence. As such, we could not have confidence in our ability to determine if the observed effects, though small, were statistically significant. Therefore, we sought to increase our sample size to an adequate level by aggregating students from all four content areas resulting in a total sample size of N = 1,624 (i.e., 821 in each group, PBL and non-PBL).

We then ran another independent samples *t* test to examine differences in average gain scores based on group membership (PBL versus non-PBL). The *t* test did not return a statistically significant result (t[1,640] = -1.729, p = .08). However, as we observed in the content area analyses, the PBL group outgained the non-PBL group by a small margin (mean difference of -.063). The observed difference translates to an estimated effect size of d = .08 or a *very small effect* (i.e., a small effect is equal to at least .10 according to Cohen).

We calculated the observed power for a two-tailed independent samples *t* test, wherein a small effect (d = .08) was observed with a sample size of 1,642. The result was .90 or 90% confidence. We concluded that, even after aggregating across content areas, we did not have adequate power to reach 95% confidence in a very small effect. However, our analysis indicated that, with 90% confidence, the very small effect we observed for PBL membership was not statistically significant (p = .08). If we were to relax the criterion for significance to p = .10 in light of the exploratory nature of this study, we would have achieved statistical significance, but we would still have to question the practical significance of such a small effect and rule out other explanatory variables as the source of the impact.

Discussion

This study identified a list of 21st century skills based on other available research, provided data on which of these skills teachers taught most often and extensively, and to what extent these results were related to teachers' use of project-based learning (PBL) instructional approaches and their participation in PBL professional development. The overall results provide evidence that PBL use in combination with PBL professional development can have an impact on 21st century teaching. In nearly every case the comparison suggests there are substantial differences in the hypothesized direction, with no statistically significant findings suggesting otherwise.

The study provides evidence that speaks to the potential of 21st century skills and PBL to become part of the larger educational landscape by working in different types of schools. The West Virginia Department of Education effort sought to change teaching and learning not just "in leading edge schools that have incorporated deeper learning" as highlighted by the Alliance for Excellent Education (2011, p. 4), but also in "high-poverty schools…with persistent achievement gaps" as called for by The William and Flora Hewlett Foundation (2010, p. 7). As indicated earlier, Geier, et al. (2008) and Boaler (2002) have conducted studies that indicate PBL can be effective with at-risk and diverse students. However, others have questioned the extent to which schools and teachers can foster equitable distribution of reform practices (Camburn & Won Han, 2008). It is noteworthy that in our study, 21st century skills teaching and PBL use were not limited to classes that were perceived as high achieving, but were also present in classrooms serving a majority of students whose academic performance was "behind most students their age." Ultimately, instructional innovations are aimed at preparing all students for careers and/or college. The largely rural state of West Virginia is a test case for what others are trying to do.

Teachers most often reported that they tried to develop the skills, while they least often reported that they were able to effectively assess these skills. This points to a need for advancing not just PBL practices that develop students' 21st century skills, but also assessments that are more closely aligned with PBL and 21st century skills and can be used to help guide teachers' work with students.

Another inference that can be drawn from this study is that PBL can be compatible with standardized test preparation. This is important because in their discussion of barriers to instructional reform, Wasley and Lear (2001) write "teachers abandon project-based teaching to ensure time to prepare for high-stakes tests" (p. 4). Our findings suggest that West Virginia teachers who used PBL felt no disadvantage in preparing students for these tests. Yet, we failed to reject the null hypothesis for all four content areas (English/language arts, mathematics, science and social studies). In other words, contrary to our hypothesis, we did not find that students in the PBL group achieved significantly greater gains than a matched sample of students in the non-PBL group. Due to relatively low sample sizes and small effect sizes, the content area analyses were afflicted by low statistical power. However, aggregating our data to build power did not result in a statistically significant effect for PBL. The result approached significance with approximately 90% confidence, but the difference between groups was still quite small in practi-

cality. However, it should be noted that we did observe in all four content areas and the aggregated analysis that students in the PBL group exhibited marginally higher gains than a matched set of non-PBL students. Although these results could be viewed as disappointing, they should serve to mitigate the concern among some educators that engaging in PBL will impede standardized test preparation.

The question of distribution of reform practices by teacher characteristics is also important, perhaps as important as analyzing across student and school characteristics. The finding about teachers in the PBL group offering professional development to others echoes findings from other studies suggesting that teacher engagement in leadership activities is a predictor of their success in teaching reforms (Riel & Becker, 2008). This is a concern because it suggests that the PBL teachers in our study may be teaching 21st century skills for reasons that are independent of the professional development they received. One could argue that it is a characteristic of the teacher (e.g., being a leader, innovator, or early adopter) not the PBL professional development that explains our results. It is worth noting, however, that even within teacher leaders we saw evidence that PBL may be increasing the teaching of 21st century skills. Moreover, the enthusiasm of early adopters and their ability to provide support to others is important for any scaling up initiative.

Finally, this study may be helpful in survey instrument development for future research on 21st century skills teaching. Studies could draw on the subsets of items that emerged as unique factors or use a sampling of the highest loading items across the factors to create new, more streamlined measures regarding the constructs of interest.

Limitations of the study

All studies of this nature that involve voluntary teacher participation in professional development and implementation have a risk of self-selection bias. That is, often it is the most motivated and potentially most highly effective teachers that self-select to participate in professional development and participate in voluntary research. As mentioned above, RQ1 is particularly susceptible to this bias which represents a potential threat to the validity of our findings. Finding a suitable comparison group for the PBL teachers was challenging because of unmeasured variability in this characteristic (i.e., motivation). We tried to address this by matching teachers on background characteristics as much as possible and analyzing differences in the obtained samples on a variety of measures. However, West Virginia only warehouses limited information about teachers. Therefore, we could only exercise control upon highest degree obtained and years of experience. Certainly, these measures help to model equivalent selection bias among the two groups, but we would never presume that these variables account for all differences in motivation among PBL and non-PBL teachers.

Another limitation of RQ1 is that the survey analyses used broad indices. However, subsequent analyses might focus on more specific practices and perceptions. We hope that an eventual outcome of this study will be a set of distinct and succinct indicators for teaching of 21st century skills and identification of subdimensions (e.g., two types of critical thinking) if any are evident.

Finally, the survey which addressed RQ1 asked participants in both groups to identify a target class to serve as a referent for subsequent survey items including, for example, indicators of academic press (e.g., hours of homework), the general level of student academic performance, and whether teachers used block scheduling. Because we used this approach, the analysis of survey data only represents the experience of the target class. Survey results are not necessarily representative of the breadth of instruction provided by teachers in all of their course offerings.

Several limitations of our investigation of RQ2 bear mentioning. First, in our analyses of student achievement data we were not able to include all of the teachers who took part in the BIE-sponsored professional development. Several teachers were excluded because they (a) used PBL in a course that was designated as a none-core content area (e.g., art or psychology), and as such no relevant state assessment data were available for their students; (b) implemented PBL in grade levels where students are not assessed using the statewide accountability assessment (e.g., grade 12); or because (c) we were unable to locate course records for them despite their having self-reported implementing PBL in a core content area course during SY2011. The remaining teachers who were included in our study may not represent the full breadth of PBL implementation among those teachers trained by the BIE. Exacerbating this issue, the inferential statistical tests used for this study (and most inferential tests for that matter) focus upon average differences observed between groups, and as such, variability among the students of PBL teachers and non-PBL teachers are somewhat washed out. If sample sizes were larger, and if we knew more about the quality of PBL implementation in each group, we could potentially conduct additional post hoc analyses to address this variability.

Another limitation arises from our inability to measure implementation fidelity adequately. With respect to the PBL group, we only had self-reported survey data indicating how extensively PBL was used. These data are likely subject to social desirability bias. Also, because of limitations in the course scheduling data available to us at the state level, we decided to include all available sections of the target courses self-reported by PBL teachers in our analyses. It is possible that PBL may have been implemented to varying degrees or not at all in some of these sections. Furthermore, we had no way to measure the degree to which students in target courses were actually exposed to PBL. It is certainly possible that measures such as attendance in the PBL target course could moderate its effect on achievement. Likewise, in the comparison group, we were unable to measure the presence or absence of PBL implementation. This is particularly problematic given that PBL is a common instructional modality in West Virginia, which is a Partnership for 21st Century Skills state (Partnership for 21st Century Skills, n.d.). However, we should note that our intent in conducting this study was to determine if the BIE-led PBL professional development, because of its intensity and quality, was associated with significantly different teaching practices and higher achievement gains than "business as usual" teaching in WV. We anticipated that "business as usual" teaching would include similar elements of PBL. Regardless, having a measure of PBL implementation in the comparison group used in our analyses of test scores would have been helpful.

We should also mention that our outcome measure, WESTEST 2, may be too broad to serve as an effective dependent variable for this type of study. As noted previously, our hypothesis associated with RQ2 was based upon the reasoning that PBL espouses self-directed learning and requires students to apply learned content in a procedural fashion that is similar to the re-

quirements of the 21st Century Content Standards and Objectives. Likewise, the items used on WESTEST 2, which are designed to assess these standards and which are multistep and require students to think critically and use information to solve a complex problem, require a similar set of skills. Therefore, if PBL were to enhance these essential 21st century skills, we posited that exposure to PBL may have the potential to impact performance on WESTEST 2. However, we must acknowledge that standardized tests include items that cover a wide range of standards and objectives, while a given PBL unit may focus on relatively few. For example, it is easy for one to imagine the case where a specific PBL unit is focused on teaching students a single topic such as photosynthesis. However, the end-of-year WESTEST 2 assessment for science for the corresponding grade level would include items aligned to this standard and a variety of others. In this scenario, how can we expect the students' overall test scores to be significantly impacted by her/his participation in the specific PBL unit? Had we a better measure of the content covered by the PBL unit, our results may be very different than what we have seen in this study.

Ways to avoid these limitations in future studies are addressed in the recommendations that follow.

Recommendations

The following recommendations, which are based on our findings, may help guide future research on PBL and 21st century skills.

1. *Help teachers assess 21st century skills.*

   The study found that teachers did not feel as successful at assessing the skills as they did teaching them overall. Teachers who have adopted PBL but are struggling with assessment might value continued professional development focused on assessment of 21st century skills.

2. *Design studies that control for teacher leadership.*

   Future studies might use probability sampling to avoid the problem of having teachers with extremely strong professional engagement over-represented as they were in this study. This will help provide a better test for the effectiveness of PBL use.

3. *Map outcomes to PBL more closely.*

   One of the lessons of this study is that effective research on PBL outcomes requires achievement measures that are closely matched to the standards taught by each project. When measures are closely aligned to project design, PBL has a better chance of showing an impact (e.g., Strobel and van Barneveld, 2008; Finkelstein, et al., 2010; Boss, et al., 2011). Although projects in West Virginia were mapped to standards that theoretically are assessed on WESTEST 2, there was no opportunity to establish measures for assessing each standard individually. One possible direction to explore is designing projects to meet standards in states or districts that use testing at more regular intervals on more discrete topics, e.g., incorporating more fine-grained assessments that can measure achievement on these specific standards rather than an overall score at the end of the year.

4. *Reuse and adapt the survey instrument.*

   We hope that this study can help in the development of distinct (and succinct) indicators for use in future studies that focus on teaching 21st century skills, including identification of subdimensions for closer analysis (e.g., types of critical thinking and creativity). We recommend that researchers consider using the instrument we developed to replicate findings and use our analyses to help establish measures that meet different needs, including different subsets of these skills.

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Appendix A. Survey Instrument

21st Century Teaching and Learning Survey [WVDE-CIS-28]

Thank you for agreeing to participate in this important survey. Your response will help WVDE understand more about teachers' instructional practices and how they relate to 21st Century Teaching and Learning.

There are no correct or incorrect answers. Please be candid in your responses and rest assured that the results of this survey are confidential.

We will use the information from this survey to develop a research report. However, no schools or teachers will be identified in this report. Your participation is voluntary and no one beyond the research staff will see your answers.

The WVDE understands that your time is precious. This survey should take no more than 20 minutes. Should you have any questions about this survey, please contact the Office of Research at 304.558.2546 or by e-mail (klsmith@access.k12.wv.us). We look forward to your feedback.

NOTE: In recognition of the importance of this study, we have received external support from the Buck Institute for Education that will provide $15 Amazon.com gift cards to 1 out of every 3 teachers who completes this survey.

1. Did you access this survey using a TinyURL link or an email that was sent from the WVDE?

- ◯ I clicked on the link provided in the email from the WVDE.
- ◯ I used the TinyRUL link that was faxed to our school. (Please enter the ID Code that came with your fax)

21st Century Teaching and Learning Survey [WVDE-CIS-28]

Answer for questions 1- 3. In recent years – since 2008 – has your teaching or professional development included a SIGNIFICANT FOCUS on...

1. TECHNOLOGY INTEGRATION?

◯ Yes, a significant focus in recent years

◯ No

2. FORMATIVE and BENCHMARK ASSESSMENTS?

◯ Yes, a significant focus in recent years

◯ No

3. PROJECT BASED LEARNING (PBL)?

◯ Yes, a significant focus in recent years

◯ No

4. Since 2008, have you HELPED LEAD professional development sessions -- on the above topics, or on any other significant topics?

◯ Yes

◯ No

5. In the last CALENDAR YEAR -- since JUNE 2010 -- how much time have you spent involved in professional development workshops or self-paced courses, as either a participant or facilitator? (Do not count regular school meetings or web surfing.)

Total PD time, as leader or participant, since June 2010:

◯ 0 to 10 hours ◯ 11 to 20 hours ◯ 21 to 30 hours ◯ 31 to 40 hours ◯ More than 40 hours

21st Century Teaching and Learning Survey [WVDE-CIS-28]

1. In the last 3 years (since 2008), have you participated in intensive professional development in Project-Based Learning (PBL)?

- ◯ Yes, a week long summer Teacher Leadership Institute (TLI)
- ◯ Yes, a different workshop
- ◯ No

2. THIS SEMESTER, did you use PBL in your teaching of core academic subjects -- math, science, social studies or English?

- ◯ Yes, I used PBL in core academic subjects this semester
- ◯ No, I used PBL in other subject areas
- ◯ No, I did not use PBL this semester
- ◯ Not sure

21st Century Teaching and Learning Survey [WVDE-CIS-28]

For each of the subject areas below, please indicate up to 4 classes in which you used PBL instruction this semester.

1. MATHEMATICS

	Class	Period
Math Class 1		
Math Class 2		
Math Class 3		
Math Class 4		

2. ENGLISH LANGUAGE ARTS

	Class	Period
English Class 1		
English Class 2		
English Class 3		
English Class 4		

3. SCIENCE

	Class	Period
Science Class 1		
Science Class 2		
Science Class 3		
Science Class 4		

4. SOCIAL STUDIES

	Class	Period
Social Studies Class 1		
Social Studies Class 2		
Social Studies Class 3		
Social Studies Class 4		

5. This survey asks you to pick a "TARGET CLASS". This is the class in which you felt your teaching using PBL was the most effective. (If your PBL use was equally effective in all your classes, pick any of the classes that you think learned the most).

From the classes and periods you listed above, select a TARGET CLASS, in which you used PBL.

Please refer to this TARGET CLASS when answering the rest of this survey.

21st Century Teaching and Learning Survey [WVDE-CIS-28]

For each of the subject areas below, please indicate up to 4 classes you taught this semester.

1. MATHEMATICS

	Class	Period
Math Class 1		
Math Class 2		
Math Class 3		
Math Class 4		

2. ENGLISH LANGUAGE ARTS

	Class	Period
English Class 1		
English Class 2		
English Class 3		
English Class 4		

3. SCIENCE

	Class	Period
Science Class 1		
Science Class 2		
Science Class 3		
Science Class 4		

4. SOCIAL STUDIES

	Class	Period
Social Studies Class 1		
Social Studies Class 2		
Social Studies Class 3		
Social Studies Class 4		

5. This survey asks you to pick a "TARGET CLASS". This is the class in which you felt your teaching was the most effective. (If your teaching was equally effective in all your classes, pick any of the classes that you think learned the most).

From the classes and periods you listed above, select a TARGET CLASS.

Please refer to this TARGET CLASS when answering the rest of this survey.

21st Century Teaching and Learning Survey [WVDE-CIS-28]

1. In your TARGET CLASS this semester, HOW MANY extended (week or longer) assignments, questions, projects or investigations did students complete?

Number of extended (week or longer) assignments, questions, projects or investigations:

◯ 0 ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 or more

2. How many TOTAL WEEKS were students involved in conducting these extended (week or longer) assignments, projects, investigations?

◯ none ◯ 1-2 weeks ◯ 3-4 weeks ◯ 5-6 weeks ◯ 7-8 weeks ◯ 9-10 weeks ◯ more than 10 weeks

3. What proportion of OVERALL CLASS TIME -- for the entire semester -- was devoted to these extended (week or longer) assignments, questions, projects or investigations?

For the entire semester:

◯ 0-10% of class time ◯ 11-25% of class time ◯ 26–50% of class time ◯ 51–75% of class time ◯ 76–100% of class time

4. Did your target class have block scheduling, extended periods lasting more than an hour at a time?

◯ Yes, always ◯ Yes, sometimes ◯ No

21st Century Teaching and Learning Survey [WVDE-CIS-28]

1. What is the best description of the majority of students in your target class? (Choose one.)

- ◯ Students whose academic performance is at the expected level for their age
- ◯ Students whose academic performance is behind most students their age
- ◯ Students whose academic performance is ahead of most students their age

2. This question asks for your assessment of student learning of ACADEMIC CONTENT in your target class.

Please ESTIMATE how many students in your TARGET CLASS...

	Very few	Some	Most	Nearly all
a. Have learned what they will need to know to do well on standardized tests?	◯	◯	◯	◯
b. Can apply and transfer what they have learned to new tasks and situations?	◯	◯	◯	◯
b. Feel that what they learned was personally relevant?	◯	◯	◯	◯
c. Are motivated to learn more about the subjects they studied?	◯	◯	◯	◯

3. For your target class, how many HOURS PER WEEK do you expect an average student to spend working OUTSIDE OF CLASS -- doing homework, completing assignments, or studying?

◯ Less than 1 hour per week ◯ 1-2 hours ◯ 3-5 hours ◯ 6-9 hours ◯ 10 or more hours

4. In your TARGET CLASS this semester, how much time have you spent having students practice taking standardized tests and learning to improve their TEST TAKING SKILLS?

◯ None ◯ Less than 4 hours ◯ 4 to 12 hours ◯ 13 to 20 hours ◯ More than 20 hours

21st Century Teaching and Learning Survey [WVDE-CIS-28]

The rest of this survey is going to ask about your teaching practices that might support students' learning of the following 21st century skills:

* Critical Thinking
* Collaboration
* Communication
* Creativity & Innovation
* Self-Direction
* Making Global Connections
* Making Local Connections
* Using Technology as a Tool

For each of the above you will be asked about your general teaching of these skills, and about a few specific practices you may have used.

There are no correct or incorrect answers and all responses will be kept confidential.

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, CRITICAL THINKING SKILLS refer to students being able to analyze complex problems, investigate questions for which there are no clear-cut answers, evaluate different points of view or sources of information, and draw appropriate conclusions based on evidence and reasoning.

1. Here are some examples of practices that may help students learn CRITICAL THINKING SKILLS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Compare information from different sources before completing a task or assignment?	◯	◯	◯	◯	◯
b. Draw their own conclusions based on analysis of numbers, facts, or relevant information?	◯	◯	◯	◯	◯
c. Summarize or create their own interpretation of what they have read or been taught?	◯	◯	◯	◯	◯
d. Analyze competing arguments, perspectives or solutions to a problem?	◯	◯	◯	◯	◯
e. Develop a persuasive argument based on supporting evidence or reasoning?	◯	◯	◯	◯	◯
f. Try to solve complex problems or answer questions that have no single correct solution or answer?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' critical thinking skills	◯	◯	◯	◯	◯
b. Most students have learned critical thinking skills while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' critical thinking skills	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, COLLABORATION SKILLS refer to students being able to work together to solve problems or answer questions, to work effectively and respectfully in teams to accomplish a common goal and to assume shared responsibility for completing a task.

1. Here are some examples of practices that may help students learn COLLABORATION SKILLS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Work in pairs or small groups to complete a task together?	◯	◯	◯	◯	◯
b. Work with other students to set goals and create a plan for their team?	◯	◯	◯	◯	◯
c. Create joint products using contributions from each student?	◯	◯	◯	◯	◯
d. Present their group work to the class, teacher or others?	◯	◯	◯	◯	◯
e. Work as a team to incorporate feedback on group tasks or products?	◯	◯	◯	◯	◯
f. Give feedback to peers or assess other students' work?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' collaboration skills	◯	◯	◯	◯	◯
b. Most students have learned collaboration skills while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' collaboration skills	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, COMMUNICATION SKILLS refer to students being able to organize their thoughts, data and findings and share these effectively through a variety of media, as well as orally and in writing.

1. Here are some examples of practices that may help students learn COMMUNICATION SKILLS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Structure data for use in written products or oral presentations (e.g., creating charts, tables or graphs)?	◯	◯	◯	◯	◯
b. Convey their ideas using media other than a written paper (e.g., posters, video, blogs, etc.)	◯	◯	◯	◯	◯
c. Prepare and deliver an oral presentation to the teacher or others?	◯	◯	◯	◯	◯
d. Answer questions in front of an audience?	◯	◯	◯	◯	◯
e. Decide how they will present their work or demonstrate their learning?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' communication skills	◯	◯	◯	◯	◯
b. Most students have learned communication skills while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' communication skills	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, CREATIVITY AND INNOVATION SKILLS refer to students being able to generate and refine solutions to complex problems or tasks based on synthesis, analysis and then combining or presenting what they have learned in new and original ways.

1. Here are some examples of practices that may help students learn CREATIVITY AND INNOVATION SKILLS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Use idea creation techniques such as brainstorming or concept mapping?	◯	◯	◯	◯	◯
b. Generate their own ideas about how to confront a problem or question?	◯	◯	◯	◯	◯
c. Test out different ideas and work to improve them?	◯	◯	◯	◯	◯
d. Invent a solution to a complex, open-ended question or problem?	◯	◯	◯	◯	◯
e. Create an original product or performance to express their ideas?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' creativity and innovation skills	◯	◯	◯	◯	◯
b. Most students have learned creativity and innovation skills while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' creativity and innovation skills	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, SELF-DIRECTION SKILLS refer to students being able to take responsibility for their learning by identifying topics to pursue and processes for their own learning, and being able to review their own work and respond to feedback.

1. Here are some examples of practices that may help students learn SELF-DIRECTION SKILLS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Take initiative when confronted with a difficult problem or question?	◯	◯	◯	◯	◯
b. Choose their own topics of learning or questions to pursue?	◯	◯	◯	◯	◯
c. Plan the steps they will take to accomplish a complex task?	◯	◯	◯	◯	◯
d. Choose for themselves what examples to study or resources to use?	◯	◯	◯	◯	◯
e. Monitor their own progress towards completion of a complex task and modify their work accordingly?	◯	◯	◯	◯	◯
f. Use specific criteria to assess the quality of their work before it is completed?	◯	◯	◯	◯	◯
g. Use peer, teacher or expert feedback to revise their work?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' self-direction skills	◯	◯	◯	◯	◯
b. Most students have learned self-direction skills while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' self-direction skills	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, making GLOBAL CONNECTIONS refers to students being able to understand global, geo-political issues including awareness of geography, culture, language, history, and literature from other countries.

1. Here are some examples of practices that may help students learn to make GLOBAL CONNECTIONS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Study information about other countries or cultures?	◯	◯	◯	◯	◯
b. Use information or ideas that come from people in other countries or cultures?	◯	◯	◯	◯	◯
c. Discuss issues related to global interdependency (for example, global environment trends, global market economy)?	◯	◯	◯	◯	◯
d. Understand the life experiences of people in cultures besides their own?	◯	◯	◯	◯	◯
e. Study the geography of distant countries?	◯	◯	◯	◯	◯
f. Reflect on how their own experiences and local issues are connected to global issues?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' skills in making global connections	◯	◯	◯	◯	◯
b. Most of my students have learned to make global connections while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' skills in making global connections	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, making LOCAL CONNECTIONS refers to students being able to apply what they have learned to local contexts and community issues.

1. Here are some examples of practices that may help students learn to make LOCAL CONNECTIONS.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Investigate topics or issues that are relevant to their family or community?	◯	◯	◯	◯	◯
b. Apply what they are learning to local situations, issues or problems?	◯	◯	◯	◯	◯
c. Talk to one or more members of the community about a class project or activity?	◯	◯	◯	◯	◯
d. Analyze how different stakeholder groups or community members view an issue?	◯	◯	◯	◯	◯
e. Respond to a question or task in a way that weighs the concerns of different community members or groups?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' skills in making local connections	◯	◯	◯	◯	◯
b. Most students have learned to make local connections while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' skills in making local connections	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

In general, USING TECHNOLOGY AS A TOOL FOR LEARNING refers to students being able to manage their learning and produce products using appropriate information and communication technologies.

1. Here are some examples of practices that may help students learn to USE TECHNOLOGY as TOOL FOR LEARNING.

In your teaching of your TARGET CLASS, how often have you asked students to do the following?

	Almost never	A few times a semester	1-3 times per month	1-3 times per week	Almost daily
a. Use technology or the Internet for self-instruction (e.g., Kahn Academy or other videos, tutorials, self-instructional websites, etc.)?	◯	◯	◯	◯	◯
b. Select appropriate technology tools or resources for completing a task?	◯	◯	◯	◯	◯
c. Evaluate the credibility and relevance of online resources?	◯	◯	◯	◯	◯
e. Use technology to analyze information (e.g., databases, spreadsheets, graphic programs, etc.)?	◯	◯	◯	◯	◯
f. Use technology to help them share information (e.g., multi-media presentations using sound or video, presentation software, blogs, podcasts, etc.)?	◯	◯	◯	◯	◯
g. Use technology to support team work or collaboration (e.g., shared work spaces, email exchanges, giving and receiving feedback, etc.)?	◯	◯	◯	◯	◯
h. Use technology to interact directly with experts or members of local/global communities?	◯	◯	◯	◯	◯
i. Use technology to keep track of their work on extended tasks or assignments?	◯	◯	◯	◯	◯

2. To what extent do you agree with these statements about your TARGET CLASS?

	Not really	To a minor extent	To a moderate extent	To a great extent	To a very great extent
a. I have tried to develop students' skills in using technology as a tool for learning	◯	◯	◯	◯	◯
b. Most students have learned to use technology as a tool for learning while in my class	◯	◯	◯	◯	◯
c. I have been able to effectively assess students' skills in using technology for learning	◯	◯	◯	◯	◯

21st Century Teaching and Learning Survey [WVDE-CIS-28]

1. In recognition of the importance of this study, and as a small token of appreciation, the research team will randomly select one out of every three teachers to receive a $15 gift certificate.

Do we have permission to contact you if you win an Amazon.com gift certificate?

- ◯ Yes, send me the gift if I win
- ◯ No, someone else can have it

2. If you are willing to participate in a follow-up phone call to discuss your survey responses, please let us know.

- ◯ Yes, you may call me to discuss my responses
- ◯ No, I do not want to be contacted about my responses

3. If you wish to explain any of your responses, or comment on the questions that were asked, please use this space freely.

If you have questions about this survey, please contact the WVDE Office of Research at 304.558.2546. We look forward to your feedback.

THANK YOU for COMPLETING OUR SURVEY!

This page will close when you click Done.

Appendix B. 21st Century Skills Frameworks

Students' 21st Century Skills (ITL/SRI version)

- **Knowledge Building -** Students move beyond the reproduction of information to construct knowledge that is new to them.
- **Problem-Solving and Innovation -** Students solve problems for which there is no previously learned solution, make choices in their approach, and implement their solutions in the real world.
- **Skilled Communication -** Students present their ideas in ways that are clear and compelling, and present sufficient relevant evidence on a topic or theme.
- **Collaboration -** Students work together in groups, take on roles, and produce a joint work product.
- **Self-Regulation -** Students plan and monitor their work, and make revisions based on feedback or self-assessment.
- **Use of ICT for Learning -** Students use ICT to construct knowledge; choose when, where, and how to use it; and evaluate the credibility and relevance of online resources.

The William and Flora Hewlett Foundation Deeper Learning Framework

An early draft (12/24/2010) was focused on giving students opportunities to learn

- **Content knowledge**
  - To acquire a deep understanding of the academic content
  - To apply their knowledge to novel tasks and situations
  - To create new knowledge
- **Cognitive Strategies**
  - To think critically and solve complex problems
  - To communicate effectively orally and in writing
- **Learning Behaviors**
  - To actively engage in their own learning
  - To work collaboratively with others

Their web site (as of July 15, 2012) states that deeper learning prepares students to

- **Master core academic content**
- **Think critically and solve complex problems**
- **Work collaboratively**
- **Communicate effectively**
- **Learn how to learn (e.g., self-directed learning)**

http://www.hewlett.org/programs/education-program/deeper-learning

Appendix C. Recoding Methods

Table A 1. Survey Respondent Recoding Based on Background Information From Survey Responses

	Original Category		
Recoded Category	Match	PBL	Total
Total	24	38	62
No PBL Use (N = 21)			
No emphasis on PBL	5	4	9
Emphasis on PBL, but no professional development or use	2		2
Emphasis on PBL, some professional development, but no use	5	3	8
Emphasis on PBL, extended professional development, but no use		2	2
Used PBL, limited professional development (N = 17)			
Emphasis on PBL, no professional development, but used PBL	5		5
Emphasis on PBL, only some professional development, and used PBL	7	5	12
Used PBL, extended professional development (N = 24)			
Emphasis on PBL, extended professional development, used PBL		24	24

NOTE: Of the originally identified 42 PBL teachers, 38 responded to the survey. By requiring all three criteria we lost an additional 14 PBL teachers. Keeping only the third category and combining the other two we get PBL with extended PD (N = 24) and No PBL or limited PD (N = 38)

Appendix D. Index Construction Factor Analyses

Table A 2. Factor Analysis of the Last Four 21st Century Skills

Skill Items – perceptions (highlighted with *) and frequency of practices ("I asked students to . . .")	Component			
	1	2	3	4
Global connections				
*I have tried to develop students' skills in making global connections	**.90**	.10	.11	.16
Study information about other countries or cultures?	**.88**	.03	-.09	.05
*Most of my students have learned to make global connections while in my class	**.87**	.18	.15	.22
Understand the life experiences of people in cultures besides their own?	**.86**	-.05	.09	.22
Study the geography of distant countries?	**.79**	.09	-.04	.16
*I have been able to effectively assess students' skills in making global connections	**.78**	.18	.19	.17
Use information or ideas that come from people in other countries or cultures?	**.77**	.12	.08	.12
Reflect on how their own experiences and local issues are connected to global issues?	**.76**	.11	.23	.23
Discuss issues related to global interdependency (for example, global environment trends, global market economy)?	**.71**	.25	.16	.33
Using technology				
Select appropriate technology tools or resources for completing a task?	.12	**.82**	.26	.17
*Most students have learned to use technology as a tool for learning while in my class	.15	**.80**	.37	.19
Use technology to analyze information (e.g., databases, spreadsheets, graphic programs, etc.)?	.14	**.79**	.32	.07
*I have tried to develop students' skills in using technology as a tool for learning	.26	**.77**	.25	.31
*I have been able to effectively assess students' skills in using technology for learning	.20	**.70**	.44	.16
Use technology or the Internet for self-instruction (e.g., Kahn Academy or other videos, tutorials, self-instructional websites, etc.)?	-.04	**.70**	.20	.20
Use technology to help them share information (e.g., multi-media presentations using sound or video, presentation software, blogs, podcasts, etc.)?	.15	**.65**	.33	.34
Use technology to support team work or collaboration (e.g., shared work spaces, email exchanges, giving and receiving feedback, etc.)?	.12	**.63**	.41	.29
Evaluate the credibility and relevance of online resources?	.33	**.63**	.36	.33
Use technology to interact directly with experts or members of local/global communities?	.23	**.52**	.28	.39
Use technology to keep track of their work on extended tasks or assignments?	-.05	**.48**	.24	.33

Table A 2 continued next page

Table A 2. Factor Analysis of the Last Four 21st Century Skills

Skill Items – perceptions (highlighted with *) and frequency of practices ("I asked students to . . .")	Component			
	1	2	3	4
Self-direction				
*I have been able to effectively assess students' self-direction skills	.17	.28	**.83**	.30
Plan the steps they will take to accomplish a complex task?	.03	.29	**.76**	.13
*Most students have learned self-direction skills while in my class	.17	.30	**.76**	.26
Use peer, teacher or expert feedback to revise their work?	.02	.30	**.73**	.16
Use specific criteria to assess the quality of their work before it is completed?	.17	.31	**.72**	.36
* I have tried to develop students' self-direction skills	.21	.34	**.70**	.21
Monitor their own progress towards completion of a complex task and modify their work accordingly?	.12	.25	**.69**	.31
Choose for themselves what examples to study or resources to use?	.30	.27	**.62**	.29
Take initiative when confronted with a difficult problem or question?	-.23	.31	**.59**	.14
Choose their own topics of learning or questions to pursue?	.16	.33	**.55**	.31
Local connections				
Analyze how different stakeholder groups or community members view an issue?	.25	.28	.25	**.76**
Apply what they are learning to local situations, issues or problems?	.22	.23	.27	**.72**
*Most students have learned to make local connections while in my class	.42	.23	.25	**.72**
Respond to a question or task in a way that weighs the concerns of different community members or groups?	.27	.22	.27	**.71**
Talk to one or more members of the community about a class project or activity?	.09	.42	.17	**.71**
*I have tried to develop students' skills in making local connections	.32	.21	.30	**.71**
*I have been able to effectively assess students' skills in making local connections	.41	.17	.33	**.70**
Investigate topics or issues that are relevant to their family or community?	.21	.24	.30	**.69**

Extraction method: Principal axis factoring.
Rotation method: Varimax with Kaiser normalization. Rotation converged in 6 iterations.

Table A 3. Factor Analysis of the First Four 21st Century Skills

Indicators of 21st Century Skills – First Four	Factor Number 1	2	3	4	5	6
Collaboration						
(CO) Work in pairs or small groups to complete a task together?	**.72**	-.07	.26	.15	.22	.09
(CO) Work as a team to incorporate feedback on group tasks or products?	**.70**	.36	.19	.13	.33	.16
(CO) *I have tried to develop students' collaboration skills	**.69**	.13	.07	.42	.08	.41
(CO) Work with other students to set goals and create a plan for their team?	**.66**	.38	.16	.20	.31	.11
(CO) *Most students have learned collaboration skills while in my class	**.65**	.20	.19	.45	.11	.34
(CO) Create joint products using contributions from each student?	**.59**	.49	.14	.15	.20	.20
(CO) Present their group work to the class, teacher or others?	**.56**	.42	.21	.02	.26	.10
(CT) Draw their own conclusions based on analysis of numbers, facts, or relevant information?	**.50**	.06	.39	.24	.14	.25
(CO) *I have been able to effectively assess students' collaboration skills	**.48**	.37	.31	.42	.13	.38
Communication						
(CM) Decide how they will present their work or demonstrate their learning?	.17	**.65**	.42	.26	.21	.06
(CM) *I have been able to effectively assess students' communication skills	.14	**.65**	.24	.53	.12	.30
(CM) Prepare and deliver an oral presentation to the teacher or others?	.32	**.62**	.05	.29	.38	.19
(CM) Answer questions in front of an audience?	.08	**.59**	.41	.02	.25	.17
(CM) *I have tried to develop students' communication skills	.36	**.56**	.11	.47	.13	.42
(CM) Convey their ideas using media other than a written paper (e.g., posters, video, blogs, etc.)	.25	**.49**	.27	.44	.36	.19
Creativity (with critical thinking)						
(CR) Test out different ideas and work to improve them?	.14	.20	**.76**	.24	.28	.07
(CR) Generate their own ideas about how to confront a problem or question?	.23	.18	**.71**	.20	.37	.12
(CT) Analyze competing arguments, perspectives or solutions to a problem?	.14	.28	**.66**	.15	.01	.33
(CT) Develop a persuasive argument based on supporting evidence or reasoning?	.29	.14	**.63**	.04	.09	.41
(CR) Invent a solution to a complex, open-ended question or problem?	.35	.29	**.49**	.32	.48	.07
(CT) Summarize or create their own interpretation of what they have read or been taught?	.37	.13	**.42**	.31	.01	.15
(CT) Try to solve complex problems or answer questions that have no single correct solution or answer?	.37	.13	**.39**	.12	.39	.20

Table A 3 continued next page

Table A 3. Factor Analysis of the First Four 21st Century Skills

Indicators of 21st Century Skills – First Four	Factor Number 1	2	3	4	5	6
Creativity (with communication)						
(CR) *Most students have learned creativity and innovation skills while in my class	.33	.19	.31	**.72**	.32	.22
(CR) *I have been able to effectively assess students' creativity and innovation skills	.23	.21	.26	**.69**	.42	.27
(CR) *I have tried to develop students' creativity and innovation skills	.31	.32	.26	**.60**	.28	.27
(CM) *Most students have learned communication skills while in my class	.27	.49	.18	**.54**	.20	.40
All four combined—Collaboration, critical thinking, communication and creativity						
(CO) Give feedback to peers or assess other students' work?	.42	.34	.34	.22	**.58**	.22
(CT) Compare information from different sources before completing a task or assignment?	.16	.22	.21	.18	**.55**	.33
(CM) Structure data for use in written products or oral presentations (e.g., creating charts, tables or graphs)?	.31	.19	.11	.24	**.53**	.24
(CR) Create an original product or performance to express their ideas?	.30	.43	.28	.43	**.49**	.01
(CR) Use idea creation techniques such as brainstorming or concept mapping?	.43	.34	.19	.25	**.48**	-.05
Critical thinking—Perceptions						
(CT) *I have tried to develop students' critical thinking skills	.25	.17	.21	.25	.12	**.75**
(CT) *Most students have learned critical thinking skills while in my class	.23	.13	.39	.29	.27	**.67**
(CT) *I have been able to effectively assess students' critical thinking skills	.16	.27	.31	.15	.45	**.59**

*perception items
CT = Critical thinking; CR = Creativity; CM = Communication; CO = Collaboration
Extraction method: Principal axis factoring.
Rotation method: Varimax with Kaiser normalization. Rotation converged in 40 iterations.

Table A 4. Factor Analysis of Perceptions Items for First Four 21st Century skills

	Components			
Items	1	2	3	4
Creativity				
I have been able to effectively assess students' creativity and innovation skills	**.81**	.31	.35	.24
Most students have learned creativity and innovation skills while in my class	**.80**	.27	.31	.36
I have tried to develop students' creativity and innovation skills	**.76**	.29	.36	.31
Critical thinking				
I have been able to effectively assess students' critical thinking skills	.21	**.81**	.39	.12
Most students have learned critical thinking skills while in my class	.35	**.79**	.2	.32
I have tried to develop students' critical thinking skills	.22	**.79**	.16	.37
Communication				
I have been able to effectively assess students' communication skills	.34	.28	**.82**	.23
Most students have learned communication skills while in my class	.42	.3	**.73**	.37
I have tried to develop students' communication skills	.39	.3	**.69**	.41
Collaboration				
I have tried to develop students' collaboration skills	.29	.28	.21	**.84**
Most students have learned collaboration skills while in my class	.30	.28	.36	**.78**
I have been able to effectively assess students' collaboration skills	.35	.37	.46	**.62**

Extraction method: Principal axis factoring.
Rotation method: Varimax with Kaiser normalization. Rotation converged in 5 iterations.

Appendix E. Research Question 1 Data Analysis Tables

Table A 5. Time on Professional Development, Extended Assignments, and Perceived Outcomes, by PBL Use

'Item	Total Mean	SD	Mean No PBL or Limited PD (Low N = 37)	Mean PBL with extended PD (N = 24)	Effect Size	*p* <
Time spent in professional development (1 = 0 to 10 hours, 2 = 11–20, 3 = 21–30, 4 = 31–40, 5 = 40 or more)	3.19	1.60	2.87	3.71	.53	*.05*
Number of extended (week or longer) assignments (1 = 0, 2 = 1, 3 = 2, 4 = 3, 5 = 4, 7 = 6 or more)	3.50	1.45	3.37	3.71	.24	*.37 (NS)*
Total weeks of extended assignments (1 = none, 2 = 1–2 weeks, 3 = 3–4, 4 = 5–6, 5 = 7–8, 6 = 9–10, 7 = more than 10)	3.37	1.71	3.08	3.83	.44	*.09 (NS)*
Proportion of class time devoted to extended assignments (1 = 0–10%, 2 = 11–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%)	2.31	1.18	2.05	2.71	.56	*.05*
Time spent having students practice taking standardized tests (1 = none, 2 = less than 4, 3 = 4–12 hours, 4 = 13–20, 5 = more than 20)	2.60	1.00	2.66	2.50	-.16	*.55 (NS)*
Hours per week an average student is expected to work OUTSIDE OF CLASS (1 = less than 1, 2 = 1–2, 3 = 3–5, 4 = 6–9, 5 = 10 or more)	2.56	.90	2.66	2.42	-.27	*.31 (NS)*
To what extent students in the selected class (1 = very few, 2 = some, 3 = most, 4 = nearly all)						
Learned what they will need to know to do well on standardized tests?	3.00	.75	2.84	3.25	.55	*.05*
Feel that what they learned was personally relevant?	3.00	.72	2.92	3.13	.28	*.28 (NS)*
Can apply and transfer what they have learned to new tasks and situations?	2.95	.73	2.76	3.25	.66	*.01*
Are motivated to learn more about the subject they studied?	2.84	.73	2.68	3.08	.55	*.05*

Table A 6. Mean 21st Century Skills Correlated to Professional Development and Extended Assignments

Correlations In the last year….	Mean *z* score 21st century skills	Time PD	Number extended	Total weeks	Overall class time
Time spent involved in professional development workshops or self-paced courses	.34**	1.00			
Number of extended (week or longer) assignments, questions, projects or investigations	.47***	0.15	1.00		
How many TOTAL WEEKS were students involved in conducting these extended (week or longer) assignments, projects, or investigations?	.29*	.25*	.44***	1.00	
What proportion of OVERALL CLASS TIME -- for the entire semester -- was devoted to these extended (week or longer) assignments, questions, projects or investigations?	.35**	.26*	.31*	.47***	1.00

*** $p < .001$
** $p < .01$
* $p < .05$
Low $n = 61$

Table A 7. Independent Samples T Test of Means, by PBL Use

Mean comparison: PBL with extended PD vs. no PBL or limited PD	Equal variances assumed?	Levene's test for equality of variances		*T* test for equality of means						
									95% confidence interval of the difference	
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean difference	Std. Error difference	Lower	Upper
Mean 21st Century Skills Index scores by PBL use										
	Yes	.138	.712	-3.88	60.00	.000	-.91	.23	-1.38	-.44
	No			-3.94	51.68	.000	-.91	.23	-1.38	-.44
Mean on teacher-reported outcomes by PBL Use										
Learned what they need for standardized tests?	Yes	5.03	.03	-2.16	60.00	.035	-.41	.19	-.79	-.03
	No			-2.37	59.95	.021	-.41	.17	-.75	-.06
Can apply and transfer what they have learned to new tasks and situations?	Yes	.44	.51	-2.67	60.00	.010	-.49	.18	-.85	-.12
	No			-2.62	45.83	.012	-.49	.19	-.86	-.11
Feel that what they learned was personally relevant?	Yes	.37	.55	-1.08	60.00	.284	-.20	.19	-.58	.17
	No			-1.11	52.59	.274	-.20	.18	-.57	.17
Are motivated to learn more about the subjects they studied?	Yes	3.52	.07	-2.16	60.00	.035	-.40	.18	-.77	-.03
	No			-2.23	53.46	.030	-.40	.18	-.76	-.04
Mean on teacher reported academic press, by PBL use										
Hours of test preparation	Yes	1.743	.192	1.03	60.00	.307	.24	.23	-.23	.71
	No			1.08	56.47	.284	.24	.22	-.20	.69
Hours outside of class	Yes	.998	.322	.60	60.00	.549	.16	.26	-.37	.68
	No			.62	53.23	.539	.16	.26	-.35	.67
Extended (week or longer) assignments, questions, projects or investigations										
Number of extended assignments	Yes	.09	.76	-.90	60.00	.372	-.34	.38	-1.10	.42
	No			-.92	52.36	.362	-.34	.37	-1.08	.40
TOTAL WEEKS were students involved	Yes	.05	.82	-1.72	60.00	.091	-.75	.44	-1.63	.12
	No			-1.73	49.93	.090	-.75	.44	-1.63	.12
Proportion of OVERALL CLASS TIME–for semester	Yes	.15	.70	-2.19	59.00	.033	-.65	.30	-1.25	-.06
	No			-2.25	54.07	0.028	-0.65	0.29	-1.24	-0.07
Mean 21st Century Skills by teacher involvement in professional development										
Time spent involved in PD in the last year	Yes	.002	.96	-2.07	6.00	.043	-.84	.41	-1.65	-.03
	No			-2.09	50.55	.042	-.84	.40	-1.65	-.03
Teachers who had led PD since 2008 (ignoring PBL use)	Yes	1.884	.175	-3.13	60.00	.003	-.76	.24	-1.25	-.28
	No			-2.99	41.40	.005	-.76	.25	-1.28	-.25
By PBL use, for teachers who had led PD	Yes	1.489	.230	-2.70	36.00	.011	-.71	.26	-1.25	-.18
	No			-2.92	33.93	.006	-.71	.24	-1.21	-.22

Table A 8. ANOVA Tests for Mean 21st Century Skills

Mean on 21st century skills index by…	Between groups					Within groups			Total	
	Sum of squares	*df*	Mean square	*F*	Sig	Sum of squares	*df*	Mean square	Sum of squares	Df
PBL use (3-category)										
	14.97	2	7.48	9.59	.000	46.030	59	0.780	61.00	61
Mean on 21st Century Skills Index by academic performance level indicated by the teacher (ignoring PBL)										
	3.923	2	1.961	1.959	.150	57.059	57	1.001	60.981	59
Mean on 21st Century Skills Index by PBL use, within academic performance level										
Ahead of most	.815	1	.815	.938	.340	17.371	20	.869	18.186	21
Behind most	5.652	1	5.652	9.102	.010	6.830	11	.621	12.482	12
At the expected level	7.532	1	7.532	9.186	.006	18.859	23	.820	26.391	24
Mean on 21st Century Skills Index by block scheduling category (ignoring PBL)										
	4.591	2	2.296	2.401	.100	56.409	59	.956	61.000	61
Mean on 21st Century Skills Index by PBL use, within block scheduling category										
No block schedule	6.434	1	6.434	8.976	.005	24.371	34	.717	30.806	35
Sometimes	1.144	1	1.144	7.575	.050	.604	4	.151	1.747	5
Always	2.863	1	2.863	2.454	.135	20.993	18	1.166	23.856	19

Red denotes nonsignificance.

Table A 9. Independent Samples T Tests of Means for Each Skill, by PBL Use

Practice score index	Equal variances assumed?	Levene's test for equality of variances		*T* test for equality of means						
									95% confidence interval of the difference	
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean difference	Std. error difference	Lower	Upper
Critical thinking	Yes	1.81	.18	-3.11	60.00	.003	-.57	.18	-.94	-.21
	No			-3.31	57.80	.002	-.57	.17	-.92	-.23
Collaboration	Yes	.47	.50	-4.34	60.00	.000	-.84	.19	-1.22	-.45
	No			-4.46	53.26	.000	-.84	.19	-1.21	-.46
Communica-tion	Yes	.00	.96	-4.71	60.00	.000	-.86	.18	-1.23	-.50
	No			-4.58	44.46	.000	-.86	.19	-1.24	-.48
Creativity and innovation	Yes	.03	.86	-3.95	60.00	.000	-.78	.20	-1.18	-.39
	No			-4.03	52.01	.000	-.78	.19	-1.17	-.39
Self direction	Yes	.38	.54	-2.73	60.00	.008	-.55	.20	-.95	-.15
	No			-2.79	52.79	.007	-.55	.20	-.94	-.15
Global connections	Yes	.26	.61	-.12	60.00	.905	-.03	.23	-.48	.43
	No			-.12	5.90	.904	-.03	.23	-.48	.42
Local connections	Yes	1.48	.23	-3.09	60.00	.003	-.66	.21	-1.08	-.23
	No			-2.99	43.99	.005	-.66	.22	-1.10	-.22
Technology as a tool	Yes	.03	.86	-3.60	60.00	.001	-.70	.19	-1.09	-.31
	No			-3.65	51.39	.001	-.70	.19	-1.08	-.31

Red indicates results that were not significant.

Table A 10. Means on Practices Items for Each Skill, by PBL Use

In your teaching of your TARGET CLASS, how often have you asked students to do the following? Scale: 1 = Almost never; 2 = A few times a semester; 3 = 1–3 times per month; 4 = 1–3 times per week; 5 = Almost daily	Total mean	*SD*	Mean no PBL or limited PD (*n* = 38)	Mean PBL with extend-ed PD (*n* = 24)	Effect Size
Critical thinking skills					
Summarize or create their own interpretation of what they have read or been taught?	4.03 [a]	.89	3.84	4.33	.55*
Draw their own conclusions based on analysis of numbers, facts, or relevant information?	3.97[a]	.96	3.74	4.33	.62*
Analyze competing arguments, perspectives or solutions to a problem?	3.39	1.00	3.16	3.75	.59*
Try to solve complex problems or answer questions that have no single correct solution or answer?	3.34	1.09	3.05	3.79	.68**
Develop a persuasive argument based on supporting evidence or reasoning?	2.97	1.12	2.61	3.50	.79**
Compare information from different sources before completing a task or assignment?	2.92	1.18	2.82	3.08	.23(ns)
Collaboration skills					
Work in pairs or small groups to complete a task together?	4.21 [a]	.83	3.95	4.63	.81***
Work with other students to set goals and create a plan for their team?	3.28	1.08	2.97	3.75	.72**
Create joint products using contributions from each student?	3.24	1.15	2.76	4.00	1.07***
Present their group work to the class, teacher or others?	3.03	.96	2.76	3.46	.73**
Work as a team to incorporate feedback on group tasks or products?	2.95	1.12	2.61	3.52	.82***
Give feedback to peers or assess other students' work?	2.87	1.11	2.50	3.46	.86***
Communication skills					
Answer questions in front of an audience?	3.03	1.34	2.68	3.58	.67**
Structure data for use in written products or oral presentations (e.g., creating charts, tables or graphs)?	2.82	1.11	2.50	3.33	.75**
Decide how they will present their work or demonstrate their learning?	2.71	1.00	2.37	3.25	.88***
Convey their ideas using media other than a written paper (e.g., posters, video, blogs, etc.)	2.66	1.07	2.26	3.29	.96***
Prepare and deliver an oral presentation to the teacher or others?	2.44	.95	2.05	3.04	1.04***

Table A 10 continued next page

Table A 10. Means on Practices Items for Each Skill, by PBL Use

In your teaching of your TARGET CLASS, how often have you asked students to do the following? Scale: 1 = Almost never; 2 = A few times a semester; 3 = 1–3 times per month; 4 = 1–3 times per week; 5 = Almost daily	Total mean	*SD*	Mean no PBL or limited PD (*n* = 38)	Mean PBL with extend-ed PD (*n* = 24)	Effect Size
Creativity & innovation skills					
Generate their own ideas about how to confront a problem or question?	3.35	1.09	3.03	3.87	.78**
Use idea creation techniques such as brainstorming or concept mapping?	2.97	1.12	2.74	3.33	.53*
Test out different ideas and work to improve them?	2.95	1.15	2.58	3.54	.84***
Invent a solution to a complex, open-ended question or problem?	2.61	1.01	2.32	3.08	.76**
Create an original product or performance to express their ideas?	2.57	1.09	2.16	3.21	.96***
Self-direction skills					
Take initiative when confronted with a difficult problem or question?	3.42	1.17	3.21	3.75	.46(*ns*, .08)
Use peer, teacher or expert feedback to revise their work?	3.11	1.33	2.89	3.46	.42(*ns*, .10)
Plan the steps they will take to accomplish a complex task?	2.95	1.21	2.68	3.38	.57*
Use specific criteria to assess the quality of their work before it is completed?	2.89	1.22	2.53	3.46	.77**
Monitor their own progress towards completion of a complex task and modify their work accordingly?	2.81	1.23	2.55	3.21	.53*
Choose for themselves what examples to study or resources to use?	2.65	1.17	2.45	2.96	.43(*ns*, .10)
Choose their own topics of learning or questions to pursue?	2.32	1.07	2.05	2.75	.65**
Global connection skills					
Reflect on how their own experiences and local issues are connected to global issues?	2.54	1.21	2.51	2.58	.06(*ns*)
Understand the life experiences of people in cultures besides their own?	2.44	1.22	2.45	2.42	-.03(*ns*)
Study information about other countries or cultures?	2.37	1.19	2.45	2.25	-.17(*ns*)
Discuss issues related to global interdependency (for example, global environment trends, global market economy)?	2.35	1.24	2.29	2.46	.14(*ns*)
Use information or ideas that come from people in other countries or cultures?	2.18	1.08	2.13	2.25	.11(*ns*)
Study the geography of distant countries?	1.88	1.18	1.89	1.88	-.01(*ns*)

Table A 10 continued next page

Table A 10. Means on Practices Items for Each Skill, by PBL Use

In your teaching of your TARGET CLASS, how often have you asked students to do the following? Scale: 1 = Almost never; 2 = A few times a semester; 3 = 1–3 times per month; 4 = 1–3 times per week; 5 = Almost daily	Total mean	*SD*	Mean no PBL or limited PD (*n* = 38)	Mean PBL with extend-ed PD (*n* = 24)	Effect Size
Local connection skills					
Apply what they are learning to local situations, issues or problems?	2.74	1.19	2.50	3.13	.53*
Investigate topics or issues that are relevant to their family or community?	2.63	1.16	2.37	3.04	.58*
Respond to a question or task in a way that weighs the concerns of different community members or groups?	1.92 b	1.00	1.66	2.33	.68**
Talk to one or more members of the community about a class project or activity?	1.90	.94	1.61	2.38	.82***
Analyze how different stakeholder groups or community members view an issue?	1.87	1.00	1.61	2.29	.69**
Using technology as a tool for learning skills					
Select appropriate technology tools or resources for completing a task?	3.27	1.16	2.89	3.88	.84***
Use technology or the Internet for self-instruction (e.g., Kahn Academy or other videos, tutorials, self-instructional websites, etc.)?	2.94	1.32	2.61	3.46	.65**
Use technology to analyze information (e.g., databases, spreadsheets, graphic programs, etc.)?	2.92	1.22	2.58	3.46	.72**
Use technology to help them share information (e.g., multi-media presentations using sound or video, presentation software, blogs, podcasts, etc.)?	2.82	1.26	2.47	3.38	.71**
Use technology to keep track of their work on extended tasks or assignments?	2.69	1.38	2.32	3.25	.67**
Evaluate the credibility and relevance of online resources?	2.63	1.30	2.26	3.21	.73**
Use technology to support team work or collaboration (e.g., shared work spaces, email exchanges, giving and receiving feedback, etc.)?	2.48	1.29	2.03	3.21	.92***
Use technology to interact directly with experts or members of local/global communities?	1.77	1.12	1.61	2.04	.39(ns)

*** $p < .001$, ** $p < .01$, * $p < .05$ [a] Min/Max = 2/5 [b] Min/Max = 1/4

NOTE: Statistical significance is based on Independent Samples *t* tests, available from the author.

Table A 11. Independent Sample *T* Tests for 21st Century Skills by PBL Use Within Subjects

Practice index	Equal variances assumed?	Levene's test for equality of variances		*t*-test for equality of means						
									95% confidence interval of the difference	
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean difference	Std. Error difference	Lower	Upper
Math	Yes	.65	.43	-3.47	21.00	.002	-1.38	.40	-2.21	-.55
	No			-3.25	13.59	.006	-1.38	.42	-2.29	-.47
Science	Yes	.30	.59	-1.87	11.00	.088	-.61	.32	-1.32	.11
	No			-1.89	1.99	.085	-.61	.32	-1.31	.10
Social Studies	Yes	2.54	.14	-.77	11.00	.455	-.47	.61	-1.82	.87
	No			-.95	9.78	.363	-.47	.50	-1.59	.64
English	Yes	.82	.38	-2.11	11.00	.058	-.99	.47	-2.03	.04
	No			-1.98	7.01	.088	-.99	.50	-2.17	.19

Red indicates results that were not significant.

Table A 12. Mean 21st Century Skills Z-Scores Across Subject Areas

	Mathematics (n = 23)	Science (n = 13)	Social studies (n = 13)	English (n = 13)	*P* <
Overall	-.32	-.06	.36	**.26**	.18 (*ns*)
Critical thinking skills	-.10	.04	.12	.01	*ns*
Collaboration skills	-.18	.18	-.02	.18	*ns*
Communication skills	-.23	.13	.12	.16	*ns*
Creativity and innovation skills	-.14	-.12	.17	.21	*ns*
Self-direction skills	-.14	-.20	.02	.43	.17 (*ns*)
Making global connections	-.57	-.28	1.10	.16	$p < .001$
Making local connections	-.28	.00	.39	.12	.15 (*ns*)
Using technology as a tool	-.12	-.03	.08	.16	*ns*

Table A 13. ANOVA Test of Differences in 21st Century Skills by Subject Area

Subject taught	Between groups					Within groups			Total	
	Sum of squares	*df*	Mean square	*F*	*Sig*	Sum of squares	*df*	Mean square	Sum of squares	*df*
Overall – all skills combined	4.939	3	1.646	1.703	.176	56.061	58	.967	61	61
Critical thinking	.441	3	.147	.248	.863	34.373	58	.593	34.813	61
Collaboration	1.609	3	.536	.769	.516	4.484	58	.698	42.093	61
Communication	2.004	3	.668	.986	.406	39.299	58	.678	41.303	61
Creativity & innovation	1.597	3	.532	.750	.527	41.176	58	.71	42.773	61
Self-direction	3.358	3	1.119	1.714	.174	37.881	58	.653	41.24	61
Global connections	24.67	3	8.223	22.503	.001	21.195	58	.365	45.865	61
Local connections	4.021	3	1.34	1.837	.15	42.317	58	.73	46.338	61
Using technology as a tool for learning	.758	3	.253	.360	.782	4.666	58	.701	41.424	61

Red indicates results that were not significant.

Table A 14. Chi-Square Test For Distribution by PBL Category

Distribution by PBL use		Value	*df*	Asymp. Sig. (2-sided)
Class academic performance indicator by PBL category	Pearson chi-square	2.451[a]	4	.653
	Likelihood ratio	2.459	4	.652
	Linear-by-linear association	.779	1	.378
	N of valid cases	60		
Block scheduling by PBL category	Pearson chi-square	3.352[b]	4	.501
	Likelihood ratio	3.311	4	.507
	Linear-by-linear association	.016	1	.900
	N of valid cases	62		
Leading professional development since 2008 by PBL category	Pearson chi-square	24.731[c]	1	.000
	Likelihood ratio	32.745	1	.000
	Linear-by-linear association	24.332	1	.000
	N of valid cases	62		

a. 2 cells (22.2%) have expected count less than 5. The minimum expected count is 3.47.
b. 3 cells (33.3%) have expected count less than 5. The minimum expected count is 1.65.
c. 0 cells (.0%) have expected count less than 5. The minimum expected count is 9.29. b. Computed only for a 2x2 table.

Appendix F. Research Question 2 Data Analysis Tables

Covariate 1: District

Chi-Square statistics were significant when examining the variable "district" for all four content areas. Therefore, we conducted additional Factorial ANOVAs to verify that the treatment*district interaction was not significant. The following tables present the results and interaction effects appear in green text. None of the interaction effects were significant.

Table A 15. Factorial ANOVA Results for "District" and Dependent Variable: Math Gain

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	25.817[a]	18	1.434	3.197	.000
Intercept	.012	1	.012	.027	.871
treatm	1.302	1	1.302	2.901	.090
CRQDIS	23.608	14	1.686	3.758	.000
treatm * CRQDIS	.954	3	.318	.709	.548
Error	91.985	205	.449		
Total	117.893	224			
Corrected Total	117.802	223			

a. R Squared = .219 (Adjusted R Squared = .151)

Table A 16. Factorial ANOVA Results for "District" and Dependent Variable: RLA Gain

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	8.966[a]	22	.408	.977	.493
Intercept	1.409	1	1.409	3.379	.067
treatm	.019	1	.019	.046	.830
CRQDIS	6.874	18	.382	.916	.560
treatm * CRQDIS	.322	3	.107	.258	.856
Error	175.600	421	.417		
Total	186.503	444			
Corrected Total	184.566	443			

a. *R* Squared = .049 (Adjusted *R* Squared = -.001)

Table A 17. Factorial ANOVA Results for "District" and Dependent Variable: Science Gain

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	26.166[a]	15	1.744	2.882	.000
Intercept	.196	1	.196	.324	.569
treatm	.531	1	.531	.877	.349
CRQDIS	25.151	12	2.096	3.462	.000
treatm * CRQDIS	.836	2	.418	.690	.502
Error	351.097	580	.605		
Total	377.263	596			
Corrected Total	377.263	595			

a. *R* Squared = .069 (Adjusted *R* Squared = .045)

Table A 18. Factorial ANOVA Results for "District" and Dependent Variable: Social Studies Gain

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	25.693[a]	20	1.285	2.518	.000
Intercept	4.781	1	4.781	9.370	.002
treatm	.006	1	.006	.012	.912
CRQDIS	24.160	17	1.421	2.786	.000
treatm * CRQDIS	.610	2	.305	.597	.551
Error	182.145	357	.510		
Total	207.841	378			
Corrected Total	207.838	377			

a. *R* Squared = .124 (Adjusted *R* Squared = .075)

Covariate 2: Race

Chi-Square statistics were significant when examining the variable "race" only for reading/language arts. Therefore, we conducted an additional Factorial ANOVA to verify that the treatment*race interaction was not significant. The following table presents the results and the interaction effect appears in green text. The interaction effect was not significant.

Table A 19. Factorial ANOVA Results for "Race" and Dependent Variable: Reading/Language Arts Gain

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	2.541[a]	5	.508	1.223	.297
Intercept	.004	1	.004	.011	.917
treatm	.009	1	.009	.022	.883
RACE	1.995	3	.665	1.600	.189
treatm * RACE	.037	1	.037	.090	.765
Error	182.025	438	.416		
Total	186.503	444			
Corrected Total	184.566	443			

a. *R* Squared = .014 (Adjusted *R* Squared = .003)

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Jorea M. Marple, Ed.D.
State Superintendent of Schools