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Can online professional development increase teachers' success in implementing project-based learning in south China?

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Abstract

Purpose – The purpose of this study is to evaluate the effectiveness of one online PD in PBL. Researchers want to investigate if a five-day international online PBL training will prepare teachers to implement PBL in their classrooms. Secondly, the researchers aim to determine if the training provides teachers with sufficient knowledge and support to ensure successful PBL implementation.

Design/methodology/approach – Participants were given a 5-day (20 h) online PBL training created by one of the researchers with three frontline teachers. Seven trainers are divided into four groups for four groups of participants. Group A included Grade 1 and Grade 2 teachers, Group B included Grade 3 and Grade 4 teachers, Group C included Grade 5 and Grade 6 teachers, and Group D consisted of Grades 7 through 9 teachers. All the participants were given exactly the same surveys at the beginning and the end of the training.

Findings – Consistent with previous studies comparing in person and virtue PD programs, this five-day interactive PD program was effective in increasing teachers' knowledge of and ability to plan and implement PBL projects. Specifically, results showed that teachers' knowledge level of PBL shifted from a shallow understanding of what the name implies to a deeper, more comprehensive, and more concrete understanding of PBL essential concepts, its pedagogical values, specific process involved in a PBL project. In addition, the PD program increased teachers' comfort level and ability of planning and implementing PBL projects across grade levels and subject areas.

Originality/value – This research study supported the previous study results that virtual PD programs can be as effective as in person programs. Further, this is the study discovered the effectiveness of PBL training between the US and China through online format, which has not been conducted literately before. The positive results will be used to promote the online collaboration internationally in the future.

Keywords International collaboration, Project-based learning, Online professional development

Paper type Research paper

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Introduction

Project Based Learning (PBL), although not a new or novel concept, has been in the center of debate lately in the field of education across the globe. Its long history as an instructional strategy in education, especially in the fields of science and mathematics, dates back to as early as the 1900s. This literature review will discuss the history and theoretic foundations of PBL, its instructional and learning values for today's schools, challenges teachers face when implementing PBL, and formats and their effectiveness of teacher training and professional development (PD).

History and theoretic foundations

> Talk to me, I will forget,
>
> Show it to me, I will remember,
>
> Involve me, I will understand,
>
> Step back, I will act.

These often-quoted lines from the Chinese philosopher Confucius point straight to an essential component of effective teaching, learning, and student engagement. Throughout the history of education, great pedagogues have always stressed the importance of students' active engagement in the learning process. In more recent times, for example, John Dewey, an American philosopher and educator promoted 'hands-on" learning approach. Later on, Piaget and Vygotsky introduced constructivism and maintained that students should actively construct their knowledge instead of passively taking in information.

PBL, as a student-centered educational strategy, continues this line of education theory by focusing on creating opportunities for active students' engagement in their learning process. The term, PBL, was originally coined by Don Woods from McMaster University in Canada in 1960s, although it stood for Problem-Based learning then. Problem-Based Learning, as well as case-based learning and project education, was among the education innovations as alternatives to the then failing teaching method of mass lectures in universities (Graaff and Kolmos, 2007).

According to Cocco (2006), PBL is based on three constructivist principles:

(1) Learning is context-specific

(2) Learners are involved actively in the learning process

(3) Students learn through social interactions and the sharing of knowledge.

Based on the principles listed above, PBL provides students with engaging learning environment and meaningful projects from the real world, which requires authentic content, authentic assessment, and explicit educational goals (Moursund, 1999). A teacher's role in a PBL process is as a facilitator, instead of the traditional role of a director. Students should be directly involved in project designing, problem-solving, decision making, and investigative activities (Jones *et al.*, 1997; Thomas *et al.*, 1999).

Recent studies have proved the effectiveness of PBL on student learning outcomes. Ravitz (2009) discussed the positive impact of PBL on students' long-term knowledge retention and application. The Center of Excellence in Leadership of Learning (CELL) at the university of Indianapolis resonates with Ravitz's study that PBL leads to long-term knowledge retention and cultivates students' ability to apply content knowledge to problem solving. In the social aspect of student development, PBL helps produce collaboration and communication skills in students as they actively engage in PBL method

(Ravitz, 2009). Cognitively, students' critical -thinking and problem-solving skills are greatly activated and improved (Horan *et al.*, 1996). Furthermore, Chung and Chow (2004) attested to a higher degree of motivation to learn in students engaging in PBL.

Although the benefits of PBL for students' learning and development are encouraging, the implementation of the strategy in teaching is full of challenges. As a matter of fact, most teachers are not trained and therefore not prepared to implement PBL in their classrooms. Common barriers to implementing PBL effectively are the difficulties to develop authentic assessments, to meld required curriculum with PBL, to allow students sufficient autonomy, and to provide scaffolding assistance (Mentzer *et al.*, 2017) Other barriers include but not limited to: teachers' insufficient time to explore the project at hand, teachers' inability to "letting go" of the control of the learning process, classroom management difficulties, and teachers having trouble motivating students to work cooperatively as a team (Nariman and Chrispeels, 2016; Aksela and Haatainen, 2019; Marx *et al.*, 1997; Bradley-Levine *et al.*, 2010).

Due to the multitude of challenges faced by teachers in implementing PBL, teacher training and PD are key to successful PBL teaching and learning. Research has been done to investigate and explore possible effective teacher training and PD formats. There is no significant difference in terms of training effectiveness between face to face and virtual formats (Sankar and Sankar, 2010). However, the traditional one to two-day top-down workshops have been proven insufficient in adequately preparing teachers to implement PBL effectively (Marx *et al.*, 1997). Needless to say, the success of shifting a traditional classroom to a PBL classroom requires systematic changes beyond one classroom, which is beyond the scope of this research project.

Technology has had a rapid impact on K12 education since the beginning of the new century. However, it is not widely used as a means to provide professional training until the COVID-19 pandemic breaks out at the end of 2019. On the other hand, technology has also created new opportunities for creative enactment of online PD for teachers (Lee *et al.*, 2020). As for the effectiveness of online PD, the Conference Board of Mathematical Sciences (2012) found out that PD engages teachers in solving problems and deeply exploring content, which is consistent with the essence of PBL. In addition, Vrasidas and Zembylas (2004) suggested that PD should include accessible, personalized, and self-directed elements which increase opportunities for sustained, collaborative, and meaningful work among teachers, and results in increased teachers' knowledge, beliefs, and practice in the contents trained. Other researchers suggested including asynchronous discussion forums, reflection on practice, exchange ideas, and other interactive communication to improve the efficiency of professional training (Treacy *et al.*, 2002). Additionally, personalized Online PD is believed to be effective in changing teachers' instructional practice (Renninger *et al.*, 2011; Luebeck *et al.*, 2017).

Xu and Liu (2010) reported a case study conducted in Zhejiang China, they studied the effectiveness of PBL in improving self-directed learning and creative thinking. Studies investigating effectiveness of professional training in PBL for K12 teachers in China are scarce. Therefore, the purpose of this study is to evaluate the effectiveness of one online PD in PBL. Researchers want to investigate if a five-day international online PBL training will prepare teachers to implement PBL in their classrooms. Secondly, the researchers aim to determine if the training provides teachers with sufficient knowledge and support to ensure successful PBL implementation.

Research Questions.

(1) If this five-day interactive online PBL training increases teachers' knowledge and understanding of PBL?

(2) How effective is this online PBL training in preparing teachers to implement PBL in the future?

Method

The purpose of this study is to evaluate the effectiveness of the online PD in PBL for teachers in south China. Two surveys were given to 125 teachers who attended the 5-day training to evaluate their understanding of PBL and their ability to implement PBL in their classrooms in the future. 124 participants filled the pre survey and 113 participants filled the post survey.

The participants

There is a total of 124 teacher participants from school districts in southeast China attending this online professional training for the pre survey and 113 participants attended the post survey. The grades they teach are from the 1st grade through the 9th grade in all subject areas. All the teachers are required to attend this training, however, they were volunteered to attend this study.

The surveys instruments. The surveys were adopted from Kramer (2014), which were used to measure teachers' understanding of PBL and their ability to implement PBL. The researchers translated all the questions into Chinese to ensure complete understanding by the participants. The participants were first given a pretest (baseline survey, Tables A1 and A2) to measure their preexisting knowledge of PBL. Then, after a five-day online PBL training, the same group of teachers were given a posttest (post survey, Tables A3 and A4) to measure any changes incurred as a result of the training.

The two surveys contain very similar items. The Likert Scale questions are the same questions on both surveys, but the open-ended questions at the end of each survey vary. There are five open-ended, short answer questions focusing on the participants' understanding of and their ability of PBL implementation. The 5-point Likert Scale questions were set from I have never heard of this term (1) to I feel fully competent in this term (5), focusing on participants' understanding of key components defined in the PBL training (essential questions, critics, exhibitions, etc.).

Both of the surveys are delivered through a survey website called Jinshuju through which all answers can be collected in excel format. The participants accessed the survey through the link shared by the researchers. Averagely, it took approximately 15 min to complete each survey.

Design and procedure. Participants were given a 5-day (20 h) online PBL training created by one of the researchers along with other trainers in the team. The schedule of the training and the contents were listed as Tables A5. The trainers are seven experienced PBL front line teachers from a south California innovative school. The seven trainers are divided into four groups for four groups of participants. Group A included Grade 1 and Grade 2 teachers, Group B included Grade 3 and Grade 4 teachers, Group C included Grade 5 and Grade 6 teachers, and Group D consisted of Grades 7 through 9 teachers. There were approximately 30 teachers in each group. The training contents are related to the grade levels at which the participants were teaching in each group. All the participants were given exactly the same surveys at the beginning and the end of the training. Participants attended online training each morning from 8:00 to 12:00 in China time for five consecutive days. The training contents focus on the entire systematic cycle of PBL which can be seen in Tables A5.

Results

This study aimed to investigate if an online PD program would increase teachers' success in implementing PBL. Using pre- and post-surveys, teachers were asked to self-assess their knowledge about PBL and comfort level of planning and implementing a project. Open-ended questions were used to solicit answers with more specific and in-depth information. The action research design yielded results that address the three research questions, helping us

better understand the effectiveness of the online PD program in increasing teachers' knowledge of and level of motivation for PBL, as well as providing insights into developing future online PD programs.

Descriptive summary of survey data

Pre- and post-tests were distributed to all the 125 participants who attended the training. The returned responses for pre-test are 124, and 113 for post-tests, respectively. The gender ratio between female and male teachers was approximately 8:2. The majority (95%) of the participants aged below 40 years, and roughly 96% of the responders had less than 10 years' teaching experience. Most of the participants are from the lower grades in elementary (78% of the participants in the pre-survey and 85% in the post-survey), the participants taught a variety of subjects ranging from Language Arts, STEM, to Social Studies, and Physical Education (see Tables 1 and 2).

		Frequency	Percent (%)
Gender	Female	101	81.5
	Male	23	18.5
	Total	124	100.0
Age	≤30	71	57.3
	31–40	48	38.7
	41–50	4	3.2
	>50	1	0.8
	Total	124	100.0
Years of teaching	0–10	104	83.9
	11–20	16	12.9
	>20	4	3.2
	Total	124	100.0
Teaching subject(s)	AI	1	0.8
	Architecture	1	0.8
	Arts	1	0.8
	Biology	2	1.6
	Chinese	44	35.20
	English	24	19.2
	Geography	2	1.6
	History	5	4.0
	ICT	2	1.6
	Life planning	1	0.8
	Math	25	20.0
	Moral and law education	6	4.8
	Music	2	1.6
	PE	3	2.4
	Physics	1	0.8
	Psychology	2	1.6
	Science	3	2.4
	Total	125	100.0
Teaching grade(s)	Primary	90	78.3
	Middle	23	20.0
	Primary and middle	2	1.7
	Total	115	100.0

Table 1.
Pre-test demographic information at Time 1 (n = 124)

Note(s): For teaching subjects, one respondent reports teaching two subjects, so the total number is 125; for teaching grades, there are nine missing numbers, so the total number is 115

		Frequency	Percent (%)
Gender	Female	94	83.2
	Male	19	16.8
	Total	113	100.0
Age	≤30	67	59.3
	31–40	42	37.2
	41–50	3	2.7
	>50	1	0.9
	Total	113	100.0
Years of teaching	0–10	99	87.6
	11–20	10	8.8
	>20	4	3.5
	Total	113	100.0
Teaching subject(s)	AI	1	0.9
	Architecture	1	0.9
	Arts	1	0.9
	Biology	1	0.9
	Chinese	42	36.8
	Dancing	2	1.8
	English	20	17.5
	Geography	2	1.8
	History	5	4.4
	ICT	2	1.8
	Life planning	2	1.8
	Math	24	21.1
	Moral and law education	3	2.6
	Music	1	0.9
	PE	3	2.6
	Science	4	3.5
	Total	114	100.0
Teaching grade(s)	Primary	95	84.1
	Middle	17	15.0
	Primary and middle	1	0.9
	Total	113	100.0

Note(s): For teaching subjects, one respondent reports teaching two subjects, so the total number is 114

Table 2. Post-test demographic information at Time 2 (n = 113)

In the pre-survey (baseline survey), teachers were firstly asked to self-measure their understanding about seven key components of PBL (i.e. 21st Century Skills, An Entry Event, A Driving Question, A Project Calendar, A Teaching and Learning Guide, Authentic Project Assessment, Using Rubrics) using a 5-likert scale ranging from 1 (never heard of this) to 5 (fully competent). As shown in Tables 3 and 4, participants reported a general understanding of these concepts (M = 2.77), of which "A Teaching and Learning guide" and "Using Rubrics" received a relatively higher score of 3.02 than other components, whereas "A Project Calendar" and "Authentic Project Assessment" acquired the same lowest score of 2.34 out of all the components. Interestingly, there were exact same numbers (n = 73) of respondents stating they were either "never heard of this" (n = 33) or "not sure" (n = 40) about the two concepts (i.e. "A Project Calendar" and "Authentic Project Assessment"). It is also noticeable that while being asked to rate their comfort level of planning and implementing PBL projects, a relatively high mean score of 2.92 and 3.07 was respectively given (shown in Tables 5 and 6) based on a 5-point Likert scale with 1 being "not at all" and 5 being "most definitely." Overall, the initial survey demonstrated that the participant teachers had a moderate understanding about what PBL is and were generally positive about their capacity in planning and implementing PBL projects.

Comparing survey responses over time. In comparing the pre-test and post-test surveys, there was a comprehensive increase of teachers' knowledge of PBL as well as their comfort level of planning and implementing PBL projects. As shown in Tables 3 and 4, the mean score of teachers' understanding of the seven PBL elements rose from 2.77 to 3.99. Specifically, "An Entry Event" gained the highest mean score of 4.22, followed by "A Driving Question"

Table 3.
Mean, response count, and frequency for teacher understanding questions at Time 1 (n = 124)

Item	*M*	Never heard of this (%)	2 (%)	3 (%)	4 (%)	Fully competent (%)
21st Century Skills	2.91	7 (6)	41 (33)	39 (32)	30 (24)	7 (6)
An Entry Event	2.84	10 (8)	41 (33)	42 (34)	19 (15)	11 (9)
A Driving Question	2.94	9 (7)	38 (31)	39 (32)	28 (23)	10 (8)
A Project Calendar	2.34	33 (27)	40 (32)	29 (23)	20 (16)	2 (2)
A Teaching and Learning Guide	3.02	6 (5)	35 (2)	43 (35)	30 (24)	10 (8)
Authentic Project Assessment	2.34	33 (27)	40 (32)	29 (23)	20 (16)	2 (2)
Using Rubrics	3.02	6 (5)	35 (28)	43 (35)	30 (24)	10 (8)
Total	2.77	104	270	264	177	52

Note(s): 2 = not sure; 3 = vaguely familiar; 4 = somewhat familiar

Table 4.
Mean, response count, and frequency for teacher understanding questions at Time 2 (n = 113)

Item	*M*	Never heard of this (%)	2 (%)	3 (%)	4 (%)	Fully competent (%)
21st Century Skills	3.63	1 (1)	12 (11)	32 (28)	51 (45)	17 (15)
An Entry Event	4.22	0 (0)	3 (3)	13 (12)	53 (47)	44 (39)
A Driving Question	4.10	0 (0)	4 (4)	15 (13)	60 (53)	34 (30)
A Project Calendar	4.06	2 (2)	4 (4)	16 (14)	54 (48)	37 (33)
A Teaching and Learning Guide	3.99	0 (0)	4 (4)	14 (12)	74 (66)	21 (19)
Authentic Project Assessment	3.97	0 (0)	6 (5)	66 (14)	16 (58)	25 (22)
Using Rubrics	3.94	1 (1)	5 (4)	19 (17)	63 (56)	25 (22)
Total	3.99	4	38	165	371	203

Note(s): 2 = not sure; 3 = vaguely familiar; 4 = somewhat familiar

Table 5.
Mean, response count, and frequency for teacher comfort level questions at Time 1 (n = 124)

Item	*M*	Not at all (%)	2 (%)	3 (%)	4 (%)	Most definitely (%)
Planning a PBL	2.92	12 (10)	25 (20)	51(41)	33 (27)	3 (2)
Implementing a PBL	3.07	12 (10)	22 (18)	45 (36)	35 (28)	10 (8)

Note(s): 2 = somewhat; 3 = neutral; 4 = mostly

Table 6.
Mean, response count, and frequency for teacher comfort level questions at Time 2 (n = 113)

Item	*M*	Not at all (%)	2 (%)	3 (%)	4 (%)	Most definitely (%)
Planning a PBL	3.96	1 (1)	2 (2)	22 (20)	63 (56)	25 (22)
Implementing a PBL	3.90	1 (1)	2 (2)	26 (23)	62 (55)	22 (20)

Note(s): 2 = somewhat; 3 = neutral; 4 = mostly

($M = 4.10$) and "A Project Calendar" ($M = 4.06$), whereas "21st Century Skills" was ranked last on a score of 3.63. Encouragingly, there were almost no responses claiming "Never heard of this" (with a few exceptions falling into three components "21st Century Skills" ($n = 1$), "A Project Calendar" ($n = 2$), and "Using Rubrics" ($n = 1$)). Meanwhile, the number of responses noting "Fully Competent" grew by 151 (accumulated answers), an equivalent to a 290% increase after the 5-day online professional development program.

Similar results were observed regarding teachers' comfortable level of planning and implementing PBL projects. As shown in Tables 5 and 6, the mean scores of teachers' comfort level of planning and implementing a PBL project grew from 2.92 to 3.07 to 3.96 and 3.90 respectively, in which the former item's increase magnitude transcended the latter one. Moreover, only one response per each item was reported "not at all" and, in the meantime, a majority number of responses shifted to either "mostly" comfortable in planning ($n = 63$) and implementing ($n = 62$) a PBL project or "most definitely" comfortable in planning ($n = 25$) and implementing ($n = 22$) a PBL project.

A closer examination of the open-ended questions revealed more details about the change. In the knowledge dimension, there was a big shift in teachers' definitions of PBL, indicating a deeper understanding of this teaching approach. Many responses in the pre-survey defined PBL on a superficial level such as "I know it's called project-based learning," "It's a problem-oriented teaching method," or "It is a kind of research based on real-world problems, and there will be a 'product' presented in the end." However, teachers' definitions of PBL became more specific and comprehensive after the training. Notes such as "Students are guided through the project-based learning process based on problems of their interest, asking open-ended questions that allow them to grow in authentic contexts" or ". . . with a very specific project to accomplish a goal of serving a specific population and achieving certain community values . . . students make full use of their strengths and interests to learn inter disciplinarily and to acquire comprehensive skills" were rather common in the post-survey. This was also echoed in teachers' view of the effectiveness of the 5-day training. A shared comment was that the PD program has provided a road map, through which teachers learned specific steps that a PBL project may involve and mastered particular skills in designing a project, "The instructor explained each session in great detail and guided us to think deeply," as one participant remarked.

Besides acknowledging the effectiveness of the PD program in general, the majority of the participants reported their willingness to transfer knowledge into action. As demonstrated in a greater number of the participants, 80 out of 113, in the post-survey in contrast to only 20 out of 124 in the pre-survey responded "yes" to the question "Are you willing to implement a PBL project in your teaching? How would you describe such a project?" with a specific title and a brief description of the project. For example, a first-grade Chinese language teacher who hardly knew PBL and did not yet have any idea about planning or implementing a PBL project prior to the training described her planned project in the post phase as:

> . . . in these days of research, we designed a study about what a basketball brings to us. We decided to kick it off by watching a live basketball game, allowing our children to identify the core questions regarding basketball, and then we would host a basketball exhibition as our outcome. The whole school– parents, journalists, and basketball stars–will be involved. The ways we would display include: a photo gallery of our research process, video show, research presentation about the relationships between basketball, height and personality . . . and charity sales with star players signing on site to promote the sport.

Interestingly, while we noticed that there were still four responses stating "never heard of this" regarding a typical PBL concept, their corresponding answers to the question "Do you have any ideas for a project you could implement?" revealed their inclination to initiate a project in the near future, for instance, "Create a book" as noted by one teacher.

The common well-received activities and strategies about the online PD program included hands-on PBL specific activities, PBL projects demonstration and lesson studies, and PBL-related instructional toolkit. Many teachers commented that it was most beneficial for them having experienced the full process of PBL through the PD program. For example, a teacher claimed, "We have simulated the design of a project, completing it with the flow of the entire project, and got suggestions from other groups." Brainstorming and collaborative reflection and feedback were also popular among the responses as they "provided a way for me to learn from or get inspired by others" and "helped me get innovative ideas." Despite all the positive feedback, there were also issues expressed. A common concern raised by the teachers was the language and the interpretation. Some teachers mentioned that "sometimes the interpretation was rather confusing" while others noted, "the video-recorded projects demonstrated were not applicable nor practical in the context of Chinese classrooms." Some, on the other hand, complained about the lecture part being repetitive and not useful. Finally, "not having enough time to finish our project" was brought up by a few teachers.

An independent-sample T-test was run to gauge the changes between the two surveys over time (see Tables 7 and 8). Results showed that the increase between the pre- and post-tests was statistically significant, in the dimensions of both knowledge and comfort level. The detailed figures were: 21st Century Skills, t (235) = 5.75, $p < 0.001$; An Entry Event, t (235) = 11.37, $p < 0.001$; A Driving Question, t (235) = 9.56, $p < 0.001$; A Project Calendar, t (235) = 13.33, $p < 0.001$; A Teaching and Learning Guide, t (235) = 8.50, $p < 0.001$;

Variable	Time 1 M	Time 1 SD	Time 2 M	Time 2 SD	T-test T
21st Century Skills	2.91	1.01	3.63	0.90	5.75***
An Entry Event	2.81	1.10	4.22	0.75	11.37***
A Driving Question	2.94	1.07	4.10	0.76	9.56***
A Project Calendar	2.34	1.09	4.06	0.88	13.33***
A Teaching and Learning Guide	3.02	1.02	3.99	0.68	8.50***
Authentic Project Assessment	2.70	1.07	3.97	0.76	10.42***
Using Rubrics	2.56	1.14	3.94	0.81	10.61***
Planning a PBL	2.92	0.98	3.96	0.76	9.16***
Implementing a PBL	3.07	1.08	3.90	0.76	6.78***

Note(s): *$p < 0.05$
The initial results showed that there is a statistically significant increase in each item before and after the designed professional development program

Table 7.
Mean, standard deviation, and T-test for effectiveness of PBL professional development survey

Item	M-survey 1	M-survey 2
21st Century Skills	2.91	3.63
An Entry Event	2.81	4.22
A Driving Question	2.94	4.10
A Project Calendar	2.34	4.06
A Teaching and Learning Guide	3.02	3.99
Authentic Project Assessment	2.70	3.97
Using Rubrics	2.56	3.94
Planning a PBL	2.92	3.96
Implementing a PBL	3.07	3.90
Total	2.77	3.99

Table 8.
Mean responses over time: ranking knowledge of key concepts/terms (on a scale of 1–5)

Authentic Project Assessment, t (235) = 10.42, $p < 0.001$; Using Rubrics, t (235) = 10.61, $p < 0.001$; Planning a PBL project, t (235) = 9.16, $p < 0.001$; and Implementing a PBL project, t (235) = 6.78, $p < 0.001$.

Discussion

This research study was designed to examine the effectiveness of a five-day interactive online profession development program in increasing teachers' knowledge and understanding of PBL. Additionally, the study investigated if the PD program is effective in increasing teachers' comfort level and ability to plan and implement PBL projects. Pre- and Post-surveys were distributed to teachers to assess their knowledge of and ability to plan and implement PBL. Consistent with previous studies comparing in person and virtue PD programs, this five-day interactive PD program was effective in increasing teachers' knowledge of and ability to plan and implement PBL projects. Specifically, results showed that teachers' knowledge level of PBL shifted from a shallow understanding of what the name implies to a deeper, more comprehensive, and more concrete understanding of PBL essential concepts, its pedagogical values, specific process involved in a PBL project. In addition, the PD program increased teachers' comfort level and ability of planning and implementing PBL projects across grade levels and subject areas.

Despite the promising results, this research study suffers from the following limitations.

First of all, the characteristics of the sample determines the limited generalization of the study. First and foremost, although the sample covers teachers from a variety of grade levels and subject areas, the sample.

(1) Size is not large enough to generalize the findings to greater teacher population. What's more, the majority of teachers are relatively young with under 10 years teaching experience, therefore, it is unknown how would the results apply to older and more experienced teachers. Furthermore, teachers' motivation might have contributed to the positive training results. These teachers were highly motivated to learn innovative teaching methods given the fact that they signed up voluntarily to participate in the training. Lastly, the sustainability of the training was not investigated.

(2) Future research should determine how this virtual training method apply to larger teacher samples across all age and teaching experience levels. Follow-up data needs to be collected to examine the sustainability of this training method and what continued support or training might be provided to teachers for successful implementation of PBL.

Overall, this research study supported the previous study results that virtual PD programs can be as effective as in person programs.

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Appendix

Baseline survey

Table A1. Please rate your understanding of the following terms/ideas/ concepts on a scale of 1–5

	1. I have never heard of this term/ concept	2. I have heard of it, but I am not sure what this term/ concept is	3. I am vaguely familiar with this term/ concept	4. I am somewhat familiar/ knowledgeable in this term/concept	5. I feel fully competent in this term/ concept
21st Century Skills					
An Entry Event					
A Driving Question					
A Project Calendar					
A Teaching and Learning Guide					
Authentic Project Assessment					
Using Rubrics					

Table A2. Please assess your comfort level with the following

	Not at all	Somewhat	Neutral	Mostly	Most definitely
Do you feel comfortable/capable of planning a PBL project at this time?					
Do you feel comfortable/capable of implementing a PBL project at this time? (whether planned by you or someone else)					

For the following questions, please write a few sentences to share your thoughts and opinions.

(1) Based on your prior knowledge, how would you define Project Based Learning?

(2) What would help you to feel more confident in the planning of a project?

(3) What would help you to feel more confident in the implementation of a project?

(4) How do you think PBL will benefit your students?

(5) Do you have any ideas for a project you could implement?

Post survey

Table A3.
Please rate your understanding of the following terms/ideas/ concepts on a scale of 1–5

	1. I have never heard of this term/ concept	2. I have heard of it, but I am not sure what this term/ concept is	3. I am vaguely familiar with this term/ concept	4. I am somewhat familiar/ knowledgeable in this term/concept	5. I feel fully competent in this term/ concept
21st Century Skills					
An Entry Event					
A Driving Question					
A Project Calendar					
A Teaching and Learning Guide					
Authentic Project Assessment					
Using Rubrics					

Table A4.
Please assess your comfort level with the following

	Not at all	Somewhat	Neutral	Mostly	Most definitely
Do you feel comfortable/capable of planning a PBL project at this time?					
Do you feel comfortable/capable of implementing a PBL project at this time? (whether planned by you or someone else)					

For the following questions, please write a few sentences to share your thoughts and opinions.

(1) Would you consider our follow-up sessions to be effective in developing your knowledge of PBL? Why or why not?

(2) What activities/presentations were the most helpful? Why?

(3) What activities/presentations were the least helpful? Why?

(4) What strategies or methods would have been more helpful for you to gain a better understanding of Project Based Learning?

(5) How would you define Project Based Learning?

(6) How do you feel about the progress of your current project?

Day 1	
Goal	Connect with passions
	Common understanding of PBL
Connection	Passions-Based Team Name
Content	Introductions
	Passions-Based Team Name
	Significant learning (45 min)
	Introduce PBL Design Elements Reflection Tool
	Unpack a project using PBL Design Elements Reflection Tool
	What do we love about working with our students?
Exhibition	
Deliverable	Passions Team Name
	PBL Design Elements Reflection Tool Project Unpacking
	Chart - What we love about working with our students
Day 2	
Goal	Generating ideas for PBL
	Build from student passion and interest
Connection	One minute auto biography
Content	Project Card Exploration
	Give 2 Student Input questions on Backwards planner
	Empathy interviews with students (20–30 min) Introduce
	Introduce
	Backwards Planner (Student Input Question 1 & 2)
	50 Things Product Brainstorm
Exhibition	
Deliverable	PBL Design Elements Reflection Tool Project Unpacking
	Backwards Planner: Student Input
	Product Ideas
Day 3	
Goal	Generate Product and Essential Questions
	Bookends
Connection	Connecting question - How are you feeling - designing a project
Content	Pick a Product/Project Idea
	Community Connections: Authentic Audience, field work, experts
	Backwards Plan Community Connections
	Essential Question workshop
	Backwards Plan Product and Essential Question
	Critique Workshop
	Critique Essential questions
	Backwards Plan
	Critique & Revisions and any new ideas to
	Community Connections
Exhibition	
Deliverable	Backwards Planner: Community Connections
	Product Essential Question
	Critique & Revisions
Day 4	
Goal	Flesh out a project idea
Connection	Exhibition Moment
Content	Exhibition Workshop
	Reflection
	Launch workshop
Exhibition	Project Idea Gallery Walk

Table A5.
(*continued*) PBL training agenda

Deliverable	Backwards Planner - Launch - Exhibition - Reflection
Day 5	
Goal	Receive Feedback and Revise Project Idea
Connection	Connecting question -
Content	Assessment Backwards Planner Review All Section Create Calendar Project Tuning Close with a Promise
Exhibition	Project Tuning or Charette
Deliverable	Complete Project Planner - Calendar

Table A5.

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