

An investigation of teacher experiences in learning the project-based learning approach

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ABSTRACT

Project-based learning (PBL) has a positive impact on student motivation, students' perceived learning, and performance. However, many teachers are reluctant to adopt PBL. This mixed-methods study examined in-service teachers' learning experiences of planning and implementing PBL situated in a graduate level PBL course and sought insight into the challenges and ways to overcome the challenges in implementing PBL in practice. Results indicate that teachers' confidence about their ability to plan and implement a PBL project improved upon completion of the course. Nevertheless, teachers cited various obstacles, such as a lack of mentoring, planning time and implementation experiences, which had prevented them from complete implementation of PBL in teaching. Possible ways to overcome the challenges in adopting PBL include school support, opportunities for experience and practice with PBL, and peer collaboration. The study also showed that a semester-long course focused on designing and developing a PBL project of teachers' choice was effective in helping increase their confidence and experience in potential implementation of PBL in classroom practice. This study contributes to the implementation of PBL in classrooms and teacher education as well as teacher professional development on the PBL approach.

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1. INTRODUCTION

Dewey first described the benefits of hands-on, experiential learning experiences that helped shape students' understanding and encouraged their natural curiosity; more briefly stated: learning by doing [1]. Further built on the social constructivist perspective of learning, project-based learning (PBL) is "a systematic teaching method that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions" [2] PBL provides learners ways to construct their knowledge based on their personal experiences and surrounding environment [3].

The implementation of PBL is not a new concept for teachers. Constructionists argue that allowing students to be involved in hands-on learning, versus passively receiving information, enables true learning to occur [4]. This argument is still valid today since teachers have many resources to create and facilitate meaningful learning experiences. In fact, teachers are challenged now more than ever to create learning experiences that not only convey basic knowledge, but assist in developing skills that will allow students to succeed outside the classroom.

PBL is one approach teachers can leverage which takes advantage of constructivist and constructionist learning theories to provide meaningful learning experiences. PBL allows for cross-curricular learning to occur because multi-disciplinary content allows teachers to cover additional subjects when they have limited time. PBL also allows teachers to meet curriculum standards through the use of a challenging, driving question that provides an authentic learning experience for the students. Students immerse themselves in the content, acquire a deeper understanding of the topic as they apply it to real world settings. Students demonstrate their understanding while collaborating with peers, interacting with the content, and creating real-world connections [5].

Although research indicates positive outcome for students participating in PBL, the literature also illustrates ongoing challenges and issues for teachers attempting to use PBL. This demonstrates a practical dilemma: how to encourage the use of PBL to generate positive learning outcomes, while fully preparing and supporting teachers in implementing PBL? Although professional development (PD) for PBL exists, research indicates that it is not always effective in promoting its application [6], leaving us asking what can be done to increase the implementation of PBL in classrooms. Thus, research on various approaches towards preparing teachers for the application of PBL is needed. This study seeks to further understand the challenges and the experiences reported by teachers enrolled in a graduate level, semester-long course focused on the design and development of a PBL project of teachers' choice, a unique approach and context of study in terms of preparing teachers for the implementation of PBL. The paper also aims to recognize how the exposure to and practice of PBL in a PBL course affected the teachers' understanding and perceived ability towards future implementations of PBL.

2. LITERATURE REVIEW

2.1. Overview of the PBL approach

PBL is an instructional approach in which learners engage with solving a problem that helps to motivate student and create a context for creativity so students carry out finding a solution to that problem [7]. The unique aspects of PBL include (but not exclusive to) the following: investigating a topic or issue to develop a solution to an open-ended question; solving a problem (may be simulated or authentic); and designing and/or creating a product [8]. For example, instead of reading about how music and mathematics are related, students compose their own music to discover the connections for themselves [9]. In essence, PBL requires the presence of a driving question/problem that provides students an opportunity to formulate a plan, test it, and evaluate their solutions [7].

As an instructional approach, PBL has several Essential Project Design Elements for guiding the design of PBL projects. These elements include: i) Key knowledge, understanding, and success skills on content learning and 21st century skills such as collaboration and critical thinking; ii) Challenging problem or question driving the students learning and inquiry; iii) In-depth inquiry; iv) Authenticity focusing on providing students real-world authentic learning contexts; v) Student voice and choice allowing students to choose the kind of product to create and how to create it; vi) Reflection opportunities on learning; vii) Critique and revision on revising the work based on feedback; and viii) Public product requiring students to demonstrate what they have learned publicly [10]. Practitioners also use these elements as a checklist to evaluate a PBL project's design.

Research has been positive in support of PBL in content comprehension, student cognitive competencies, active participation in learning, and perceived learning outcomes [11]–[14]. Research has also revealed the positive experiences of teachers in implementing PBL [15]. However, the implementation of PBL is not without challenges. The process of planning and implementing PBL can be difficult. Teacher PD is needed to provide the necessary knowledge of PBL as well as how to implement PBL [16]. Teacher pedagogical beliefs, and their roles within the classroom, can negatively influence whether PBL is implemented fully and correctly [17]. Thus, teachers' perceived ability to use PBL in classrooms will need to be addressed.

2.2. Positive outcomes for students

PBL offers encouraging results for students when correctly implemented. Research indicates that students experience increased interest and enthusiasm for learning, as well as improved content understanding [13], [14]. PBL can also improve students' critical thinking and problem-solving skills [18], while assisting in conceptualizing difficult content [16]. These skills support student performance on a variety of tests, including traditional post-tests after PBL interventions, Advanced Placement exams, and standardized tests [19]. Students also gain an understanding of 21st century skills; abilities they can directly apply outside the classroom [13].

The positive outcomes resulting from PBL are not isolated to one specific student group. PBL has been used across grade levels from elementary [20], middle school [21], high school [22] to post-secondary students [23]. Additionally, both high and low ability students have been shown to benefit academically [24]. The use of PBL can even assist teachers in closing achievement gaps for students in lower socioeconomic status environments [11]. PBL has also been used successfully with English as a Second Language and Special Education students [25], [26].

While there are many positive outcomes associated with PBL for individual students, PBL instills a collaborative atmosphere that is not always present in traditional classrooms. Students working in groups with peers demonstrate greater appreciation for their learning, self-efficacy, and satisfaction upon completion of PBL units/lessons [21]. PBL creates an environment where students are more likely to be at ease giving and receiving constructive feedback about their work [27]. PBL supports cognitive and social growth, in addition to content knowledge by participating in real-world projects. These foundational elements are necessary for preparing self-sufficient and mindful citizens for real-world obstacles [28].

2.3. Teachers' experiences with PBL

Research on teachers' experiences with PBL have been mostly centred on the challenges faced in implementation. In looking at teachers' experiences related to PBL implementation, one theme becomes apparent: In order to have a positive experience, teachers need support from their peers, administrators, and schools. With appropriate, sustained support toward increasing teachers' competence in best practices, teachers showed confidence and positive attitude about using PBL in classrooms [29]. Teachers further improved their attitudes as they took ownership of the content, which helps sustain professional learning communities. Hernández-Ramos and De La Paz [21] noted that the positive outcomes and attitudes of students participating in PBL made teachers and administrators more optimistic about the integration of PBL into classrooms. However, even with the support of administrators and colleagues, successful PBL implementation may rely on the availability of PBL curriculum and materials. While research on positive teacher experiences is limited, it is clear that to further improve teacher experiences with PBL, we first need to address the associated implementation challenges.

2.4. Challenges and potential issues with adopting PBL

Although there are many positive outcomes when utilizing PBL in teaching and learning, PBL has not been widely implemented in classrooms [30]. This lack of implementation may be due to a lack of experience with PBL, both as educators and students. It is generally true that educators often teach in the way they were taught. With a low PBL implementation rate in general, it is unlikely teachers were taught in any PBL manner when they were students and lack first-hand knowledge of its positive aspects. Unfortunately, a lack of experience with PBL is not the only challenge teachers face, deterring many from adopting it.

2.4.1. Adoption issues with PBL

Adopting PBL into one's classroom first requires a shift in a pedagogy to a student-centred approach; one that will ultimately change the role of the teacher from being a lecturer to a facilitator [31]. The facilitator's focus is on guiding student engagement and motivation, encouraging content acquisition instead of directly supplying information through traditional lectures. This pedagogical transition represents a shift away from many established practices and pedagogies. As such, it may be challenging for teachers, as well as institutions, to embrace PBL on a significant scale, and may require reflection on content development, instructional design, and student assessment [31]. Because of the many significant changes PBL entails, it is imperative that teachers fully understand what PBL requires, and how this will impact their students, prior to adoption.

2.4.2. Challenges with the design, planning, and implementation of PBL

The design and planning of PBL lessons is among the biggest challenges for the classroom implementation. The process of design and planning a PBL project that is both simulating and authentic can be a time-consuming task [31]. Additionally, teachers must consider content standards and learning goals that the PBL curricula will cover, and develop a central idea/topic that will align to these benchmarks [32]. Assessments can also be difficult to plan, as they require substantive reconsideration of what features in a learning process are being assessed, as well as moving away from a single, summative assessment [31]. While external, pre-planned curricula exist for PBL, teachers still need to consider whether these existing templates will work for their classrooms.

Once the design of the PBL curriculum is completed, the teacher plays an equally critical role in meaningfully facilitating the student learning process. This requires a large amount of planning, as teachers must be prepared and confident in their own understanding of the material as well as their role as facilitator.

In addition to their own content knowledge, teachers need to be aware of students' prior knowledge in order to provide proper scaffolding, reflection, and assessment; all essential components of PBL [33]. Additionally, the collaborative nature of PBL requires teachers' classroom management skills that support on-topic communication, while encouraging students to work collaboratively [31].

2.5. Teacher professional development with PBL

Not all teacher PD has been found to be effective [34]. Researchers, who have examined the structure of teacher PD, found that three PD features - duration, content focus, and coherence with school learning activities - had affected teachers' knowledge/skills and change in teaching practice [35]. Wilson [34] noted that teachers being "immersed in inquiry experiences and witness(ing) models of inquiry teaching" and receiving direct instruction in the content materials are additional factors for effective PD.

PD is an essential part of implementing PBL; without proper preparation, teachers are unlikely to utilize this method [36]. Approaches for PD include online training and support, on-site coaching for teachers, and in-person training delivered in support of an externally developed PBL curriculum/unit [36]. PD for PBL can even be provided in the form of a PBL project itself. This approach not only benefits teachers' learning, but also allows them to experience PBL first hand, assisting them in their understanding of the struggles and experiences that their students may encounter [37]. No matter the approach, PD is essential in increasing teachers' confidence and competency to successfully apply PBL in practice.

2.5.1. Ongoing PD

PD for PBL is unique in that teachers are not only being trained in a new approach, but a new pedagogy that requires fundamental changes, such as beliefs toward teaching and learning [38], demanding more time and support. Kramer [6] found that teachers were unable to successfully and consistently implement PBL after their initial PD. Teachers did not feel completely comfortable or confident in their ability to implement a PBL unit on their own, and felt that they lacked support once they were in the classroom. This aligns with other research indicating that, after the initial PD, teachers need a community of support [37]. A community of support includes time to work with other teachers who implement PBL, continued PD to master PBL, and guidance within the classroom when PBL is being applied.

Teacher PD that communicates the purpose, practices, and evaluation of a PBL approach is essential for implementing this pedagogy. PD covering PBL provides teachers with a greater understanding of 21st century skills as well as information on how to implement these skills into their daily instruction [39]. In addition, PD with PBL can improve teachers' technological skills, including their basic computer skills (e.g., use of Word, PowerPoint), and online communication abilities [40]. In fact, by providing teachers with experience using PBL, these PD opportunities can change their overall belief about teaching and learning [41]. In looking for ways to support novice PBL teachers, schools need to provide opportunities for teachers to learn PBL as learners [42] and utilize professional learning communities with shared beliefs and practice, and collaborative and supportive learning for the implementation of PBL in classrooms [43]. If PBL is new to the teachers, a school may consider sending a select few teachers for ongoing training.

Research has indicated that those teachers who receive extensive PD with PBL are more likely to provide PD to other teachers [44]. Further, teachers' completion of PBL PD has been shown to improve collaboration, creating a team of support at the school or building level [37]. Additionally, as teachers' confidence and skills in PBL increase, their need for support will decrease, allowing experienced teachers to work with more novices. However, professional learning communities focusing on PBL is important for not only supporting but also sustaining teachers' effort in implementing PBL in their classrooms [43]. Within the same professional learning community, teachers can share PBL lessons as well as collaborate on designing PBL projects, which facilitates school-wide adoption of PBL.

While literature on PBL maps positive outcomes for students, challenges for teachers, and the importance of PD with PBL, no research (as far as the researchers know) has been conducted on teachers' learning experiences of planning and implementing PBL as well as the associated challenges situated in a formal course as an extended PD approach. This study looks at the experience of in-service teachers enrolled in a graduate level elective course focused on planning and implementing PBL to provide a sustained period of immersed PD experience of PBL. The study explores how we can improve teacher knowledge and confidence in PBL, combating the associated challenges in using PBL in order to increase teacher adoption of PBL. Throughout the course, the teachers (students) were introduced to the essence of the PBL pedagogy, online resources, and technology tools that would assist them in creating their own PBL unit.

3. PURPOSE OF STUDY

The purpose of this study was to investigate the experiences and perceptions of teachers in a PBL course. The researchers investigated what the perceived challenges and barriers regarding the use of PBL were, and possible ways to help overcome those challenges. We sought insight into how a PBL course could improve teacher knowledge, confidence, and perceived ability in using PBL in future classroom applications. It was our hope that this research would further the understanding of how teachers learn about PBL and how we can help teachers implement PBL. The study asked the following research questions: i) How does a formal, graduate course on PBL affect teachers' perceived ability and attitude toward the planning and implementing of PBL?; ii) What challenges and obstacles are perceived by teachers, while enrolled in a graduate level PBL course, regarding the planning and implementation of PBL in their classroom?; iii) How can we help teachers feel more confident in planning and implementing PBL in their classroom?

4. RESEARCH METHODS

4.1. A mixed-methods approach

This study utilized a mixed methods approach that “focuses on collecting, analyzing and mixing both quantitative and qualitative data in a single study” [45]. Choosing a mixed methods approach is guided by how one can best address the research questions. This study was to develop a broad understanding as to what the challenges and obstacles of using PBL are as well as how we could improve teachers' use of PBL, especially their confidence and perceived ability to use PBL in their classroom. The mixed methods approach was able to incorporate the exploratory nature of the study with multiple data collection and triangulation [46].

Figure 1 shows the multiple processes of quantitative and qualitative data collection and data analysis. In this study, quantitative data were collected from a pre-survey (prior to the PBL course) and post-survey (at the end of the course). Qualitative data were collected from teacher reflections at the end of the semester and open-ended questions in both the pre- and post-survey. To increase the number of survey participants, the pre- and post-surveys were administered in the same class with the same instructor in a different semester. During the data interpretation process, the researchers were able to triangulate the data to see if the outcomes from one type of data corroborated or contradicted the other.

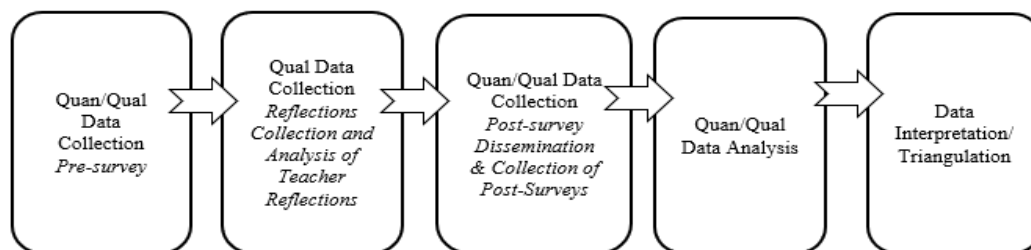


Figure 1. The mixed methods design

4.2. Context of study

The context of the study was a three-credit, graduate level elective course on PBL offered at a Northwestern university in the United States. The course was hosted completely in the course management system Moodle. The course covered: i) Characteristics and attributes of a PBL approach; ii) A teacher's role(s) as coach, mentor or tutor in guiding students through the PBL process; iii) Formative and summative assessments for monitoring and evaluating PBL unit and student outcomes; iv) Collaborative learning activities in the PBL process; v) Advantages and disadvantages of PBL and the implications for student achievement; vi) Needs of diverse learners; vii) How to align goals and objectives of PBL with state and local content standards; and viii) How to develop a PBL unit using the Buck Institute for Education's PBL model [2]. For the final project of the course, teachers developed a PBL unit for their own students. During the course, the enrolled teachers worked both independently and collaboratively. The teachers used a combination of tools throughout the course, including: classroom message boards, Google Sites, conferencing software, and resources provided by the Buck Institute for Education.

Within the course, online discussions activities were centered on exploration of issues related to PBL. Teachers participated in weekly, asynchronous discussions in Moodle. In these discussions, teachers posted reflective responses to the week's topic and left updates on their PBL unit progress. Within the online

discussions, teachers offered constructive feedback, asked questions, and cited relevant literature both from within and outside the course. Teachers were also able to edit their projects based on the feedback received from peers and the instructor.

4.3. Participants

The participants were teachers enrolled in the PBL course who were teaching while pursuing a graduate degree in educational technology. There were 21 and 15 students enrolled in the PBL course in the first and second semesters of the data collection respectively. Students who were not teaching in a K-20 (kindergarten to college) setting were excluded from this study. This left 26 K-12 or higher education educators for inclusion. Participation in the study was optional. 18 enrolled teachers completed the pre- and post-survey. Participant characteristics are presented in Table 1. There were 11 participants completed the end of semester (post-semester) reflection regarding their experience and learning in the first semester of data collection. Nine teachers completed the pre- and post- survey and the post-reflections in the first semester of data collection.

Table 1. Participants background information

Background	First semester		Second semester
	Survey participants (N/%)	Reflection participants (N/%)	Survey participants (N/%)
Gender			
Male	6 (60)	5 (45)	3 (38)
Female	4 (40)	6 (55)	5 (62)
teaching level			
elementary	3 (30)	4 (35)	4 (50)
middle school	2 (20)	1 (29)	2 (25)
High school	4 (40)	6 (29)	2 (25)
Higher education	1 (10)	0	0 (0)
Years of teaching			
1-5	2 (20)	2 (18)	5 (62)
6-10	2 (20)	2 (18)	0 (0)
11 +	6 (60)	7 (64)	3 (38)
Sub total	10	11	8

4.4. Data collection and analysis

Two kinds of data, survey and end of semester teacher reflections, were collected. Background information regarding grade levels taught, years of teaching, and participant ages was also collected as presented in Table 1.

4.4.1. Surveys

Surveys were used to collect teachers' perceptions on their competency, understanding, practices, and growth in utilizing PBL. Survey questions were centered on the Essential Project Design Elements but modified for novice teachers. The survey consisted of seven components: i) Understanding 21st century skills; ii) Utilizing an engaging entry event; iii) Developing a guiding question; iv) Creating a project calendar (to ensure a sustained inquiry); v) Creating a teaching and learning guide (focusing on content and resources); vi) Building authentic assessments; vii) and Creating assessment rubrics [10].

The survey items included five Likert-scale (Not at All, Somewhat, Neutral, Mostly, and Most Definitely) questions to assess participant comfort and confidence in using PBL regarding the above seven components, as well as open-ended questions. The pre-survey allowed the teachers to rate their content knowledge regarding essential PBL design elements. The post-survey allowed researchers to identify participants' growth regarding perceived competency and understanding of PBL as well as challenges and support for the use of PBL. The pre- and post-surveys were distributed in the first and final weeks of the course respectively. Survey data were collected from two semesters. A total of 18 students (10 from the first and eight from the second semester) completed the pre- and post-survey.

4.4.2. Reflections

At the end of the course in the first semester, teachers voluntarily completed a post-course reflection pertaining to their experiences in learning about PBL. As opposed to the short-answer questions in the survey, the reflection asked teachers to provide examples and deeper, critical insight into their learning and understanding of PBL and the challenges and obstacles for implementing PBL. Teachers were guided to

reflect on their learning experience, classroom practice, and perspectives on PBL by the following questions: i) What new perspectives and thoughts do you have since you learned about PBL?; ii) What is/are the advantage/s of using PBL in teaching?; iii) What are the challenges and obstacles from the teacher's perspective for adopting PBL in the classroom?; iv) Have you done any PBL in your class as a teacher and/or instructor as a result of taking this class? If you have, how have you practiced PBL? Please briefly describe what you have done with using PBL in your teaching.

Upon completion of the course, the reflections were downloaded from the electronic submission area in Moodle. All identifying information was removed before the data analysis. The reflections and teachers' responses to the open-ended survey questions were reviewed and coded based on themes of challenges and possible ways to overcome the challenges following an open coding process [47]. Patterns were sought in the data, and instances of the Emergent themes were recorded. Patterns were also defined and described for clarification, and Emergent themes were presented for reference in the results section. A graduate student researcher coded all the qualitative data and a faculty researcher reviewed all the coding. The two researchers agreed upon most of the coding with a few clarifications sought from the graduate student researcher.

5. RESULTS

5.1. Teachers' perceptions and perceived competency toward PBL

Most teachers (16/18) who enrolled in the PBL course had reported having little experience with PBL prior to taking the course in the pre-survey. Only a couple of teachers reported feeling confident and optimistic about their abilities in both planning and implementing a PBL unit prior to starting the course. All teachers perceived the advantages of using PBL for student learning. As seen in Table 2, upon completion of the course, teachers' overall understanding and perceived competency centered on essential PBL design elements were all higher than those in the pre-survey. The survey result demonstrated teachers' significantly increased understanding of the overall PBL approach.

Table 2. Teachers' responses to essential PBL elements

PBL essential elements	Pre-survey		Post-survey		p value
	Mean	SD	Mean	SD	
21st century skills	3.85	1.212	4.54	.708	.045*
Entry event	1.95	1.097	4.77	.417	.000**
Driving question	3.55	1.230	4.84	.388	.000**
Project calendar	3.08	1.105	4.67	.501	.000**
Teaching/learning guide	3.02	.865	4.55	.638	.000**
Authentic project assessment	2.93	1.161	4.60	.509	.000**
Creating/using assessment rubrics	4.65	.479	5.94	.177	.000***

Note. * $p < .05$, 2-tailed. ** $p < .0001$, 2-tailed.

All seven PBL components, understanding the 21st century skills ($p=0.045$), providing an entry event ($p<0.0001$), writing a driving question ($p<0.0001$), creating a project calendar ($p<0.0001$), creating a teaching and learning guide ($p<0.0001$), creating authentic project assessment ($p<0.0001$), and creating and using assessment rubrics, were found to be significantly different (Table 2) between the pre- and post- survey outcomes. The significant growth in understanding the PBL approach was highlighted in the areas of developing an entry event (with the smallest pre-mean) and creating authentic project assessment (the second smallest pre-mean), two areas covered extensively within the PBL course.

When looking at teachers' perceived ability to plan and implement a PBL unit or curriculum, the results in Table 3 revealed that there was a statistical difference ($p < .0001$) between the pre- and post-survey. Table 3 shows that upon completion of their PBL course, teachers felt more comfortable and competent with both planning and implementing a PBL unit on their own.

Table 3. Teacher perceived ability to plan and implement PBL

	Pre-survey		Post-survey		p value
	Mean	SD	Mean	SD	
Planning PBL	2.68	1.421	4.47	.672	.000**
Implementing PBL	2.76	1.209	4.34	.710	.000**

Note. ** $p < .0001$, 2-tailed.

Further evidence for teachers' increased ability and confidence in planning and implementing PBL was also revealed in their responses to open-ended post-survey questions and reflections. In response to open-ended survey questions, Table 4 shows more than half of the participating teachers (11/18) communicated their new familiarity and comfort with PBL, and more than two-thirds of the teachers (13/18) communicated their confidence in the benefit of PBL on students. Half of the teachers (9/18) expressed increased confidence in their future planning and implementing a PBL project. Other teachers (8/18) described feelings of optimism about potential PBL implementation. Several teachers (5/18) even believed that PBL would bring changes to their pedagogy and classroom practice.

Table 4. Confidence and optimism in post-survey and reflection

Emergent theme	Post-survey (frequency/number of participants)	Post-reflection (frequency/number of participants)
Confidence and optimism	Confident about student learning & benefits (13/18)	PBL increases student efficacy (10/11)
	Familiarity/comfort (11/18)	Confident about future implementation (7/11)
	Confident about Future Use (9/18)	Improved PBL confidence & application (5/11)
	Optimistic about future use & application (8/18)	Optimistic about future use & implementation (5/11)
	Confidence in PEDAGOGY SHIFT (5/18)	PBL will contribute to a positive shift to school norms (4/11)
	Optimistic of improved classroom ecology (5/18)	Optimistic about pedagogy shift (3/11)
	Hope for improved student efficacy (4/18)	

Some of these positive testimonials from different teachers included:

I think the course really did a great job of preparing for learning how to facilitate PBL. And I feel like actually "doing" PBL will still be a challenging learning experience, but one I look forward to.

I have really enjoyed this course and learning about the proper way to implement PBL. I have used projects in my class, but I struggled with PBL, which is what I really hoped to get a better grasp on. I have learned that I need to back off a little and give them (students) time to learn on their own. ... I need to spend more time probing students about their own sense-making and acquisition of skills I plan to be more conscious about this in the future so that my students can learn on their own as well as, learn from each other.

Most of the teachers (15/18) who participated in the post-survey also reported that PBL would positively transform their teaching practices and learning for their students:

Since I am a newbie, the course really exposed me to the overall picture of PBL. I truly saw the power of creating authentic, real life projects for students that focus on communication, critical thinking, and collaboration. It creates engagement through inquiry and helps to create those "sticky" learning experiences for students.

Of the eleven teachers' post-semester reflections analyzed, all reflections (11/11) expressed comfort and confidence pertaining to the PBL approach, with five teachers specifically cited the recent PBL course as being the source of their new confidence as seen in Table 4. Additionally, in looking at the categories of confidence and optimism, seven teachers expressed feelings associated with preparedness and self-assurance. One teacher shared that the PBL unit was created during the PBL course as a class project had already been implemented. Most teachers (10/11) reflected on the positive affect a PBL approach would have on meeting various student needs. Some teachers (6/11) also described how PBL would contribute to a positive shift in their teaching pedagogy. Other teachers (4/11) pointed out that PBL could positively affect their school norms, such as school culture (parent involvement and assessment adoption) and attitudes towards change as well as structures supporting students and teachers.

Teachers who were not implementing their PBL unit (10/11) at the time of writing the post-semester reflections reported that they intended to use PBL in the future:

...even without full-fledged implementation many of the techniques are applicable in a wide variety of lessons. Having experience with PBL will also help me support PBL and similar pedagogies as teachers and our school are ready to try these methods. Professionally I think all the aspects of PBL will support me in facilitating technology integration and 21st century teaching.

My work does not allow for large departures from what other teachers are doing, so I would have to convince all of the other instructors, only a few of which have strong educational backgrounds, to try a new system. However, some aspects of PBL (being a facilitator, giving the students agency, generating a personal investment for the students) are techniques that don't require a project to be used, and I learned a lot about those in this class that I didn't know previously.

All teachers (11/11) expressed positive attitudes in their post-semester reflections toward the planning, or implementation of PBL despite the fact that they were aware of the enormous amount of time required to sufficiently develop and enact PBL lessons. Most teachers (9/11) also expressed that they felt confident and prepared with sufficient knowledge of the PBL approach and were able to implement their ready-to-use unit developed in the PBL course in their own classrooms.

5.2. Perceived challenges and obstacles of implementation

The second research question examined the challenges and obstacles perceived by teachers. In both the surveys and post-semester reflections teachers identified several challenges that prevented them from pursuing PBL within their classroom. Table 5 reveals that there were seven challenges identified by teachers in the pre-survey: i) Lack of modeling or examples; ii) Lack of planning time; iii) Lack of instructions or guidance on PBL; iv) Lack of experience; v) Lack of confidence; vi) Lack of in-building support; and vii) Lack of resources.

Table 5. Perceived challenges and obstacles in surveys

Emergent theme	Pre-survey (Frequency)	Post-survey (Frequency)
Challenges and obstacles	Lack of modeling or examples (10)	Lack of implementation experience (6)
	Lack of planning time (6)	Lack of modeling or examples (5)
	Lack of instructions or guidance (5)	Lack of planning time (3)
	Lack of experience (4)	Missing collaboration (2)
	Lack of confidence (4)	Lack of instructions or guidance (2)
	Lack of in-building support (3)	
	Lack of resources (3)	

In the pre-survey, teachers (10/18) cited the lack of modeling and available examples of PBL as being the biggest challenge for them in planning or implementing their own unit. Some other challenges, expressed by teachers in the pre-survey were lack of planning time (6/18) and the need of specific instructions, resources, and guidance (5/18) for assisting them in starting PBL within their own classroom. Several teachers explained how the lack of experience or confidence (4/18) contributed to their lack of PBL implementation in response to the open-ended pre-survey questions. For example, one teacher wrote, "I am so inexperienced with (PBL), at this point, I feel like I need "baby steps with hand holding". That would be the most beneficial." In addition, the lack of in-building support and resources also prevented teachers from using PBL.

Upon completion of the course, the number of perceived challenges decreased from seven to five. Also, in Table 5, the post-survey revealed the lack of implementation experience as the top challenge. Teachers (5/18) also reported that their lack of access to examples or modeling of the PBL pedagogy in action prevented them from moving forward. Other challenges cited within the post-survey included a lack of planning time (3/18), lack of collaboration with colleagues and administrators (2/18), and lack of specific PBL instructions and guidance (2/18). At the end of the course, with more knowledge of PBL and a better sense of what the implementation of PBL would take, some teachers seemed to be nervous about actually using PBL in teaching: "I think the launch of any (PBL) project would make me nervous - there is always a fear of it flopping!" However, teachers also recognized that applying their new knowledge of PBL through implementation would ultimately boost their confidence: "(PBL) is new and a change of what I am used to. Change and new can both be hard, but just doing it is the best way to gain confidence."

The teachers' post-semester reflections provided another picture of the challenges the teachers faced in planning and implementing PBL in their own classrooms as revealed in Table 6. The most frequently cited challenge within the reflections was a lack of time to plan a PBL unit (9/11).

Table 6. Perceived challenges and obstacles in post-reflection

Emergent theme	Specific challenges/obstacles (frequency)
Challenges and Obstacles	Lack of planning time (9)
	School norms don't align with PBL (7)
	Lack of classroom time (4)
	Guidance and modeling for actual implementation (3)
	Mandated curriculum (3)
	Focus on high stakes testing (2)

The lack of planning time was echoed by concerns about having sufficient time in the classroom to properly implement PBL (4/11): “It takes time to successfully implement a PBL [lesson]. Time to introduce the activity, time to research and explore, time to create, revise, present, and debrief.”

Additionally, over half of the teachers expressed concerns in their reflections that implementing PBL would be challenging if this pedagogy did not align with their schools' norms (7/11), such as the kind of assessment adopted at their schools. Some other challenges identified in the post-semester reflections included the lack of guidance and modeling for implementing PBL (3/11), mandated curricula leaving no space for implementing a PBL unit (3/11), and the focus on high-stakes tests (2/11). One teacher explained his apprehensions over high-stakes testing, and the impact these tests have on teachers:

High-stakes tests make many teachers afraid to try innovative things. If a teacher attempts new strategies and they (the implementations of new strategies) flop, there is no “well, you learned what didn't work.” Teachers in some schools get fired in situations like this.

The nature of assessments and standardized testing at state and national levels could overburden teachers trying to implement PBL units. PBL can be difficult to plan and implement without the understanding and appropriate support from the school, as one teacher humorously tried to explained, “Creating a successful PBL is a lot like juggling while constantly having someone throw an extra item into your routine.”

In summary, the qualitative results in Table 2 showed that the main challenge of implementing PBL is not the lack of knowledge as cited in the pre-survey (e.g., lack of PBL modeling or examples), which corroborated with the quantitative result of the significant increase of teachers' overall knowledge of essential PBL design elements after the PBL course. The teacher reflections indicated trends in their perceived challenges and obstacles of planning and implementing PBL that echoed previous literature of challenges regarding pedagogical shifts in classrooms. While school cultures will likely be shaped by local or temporal factors, teachers wishing to make pedagogical changes, such as implementing the PBL approach, face pressures beyond their personal factors (e.g., a lack of experience or knowledge).

5.3. Increasing teachers' confidence in applying PBL

Research question three asks how we can help teachers feel more confident in planning and implementing PBL in their classroom. This question was addressed with open-ended questions in surveys, where teachers were asked specifically what would help them feel more confident in planning and implementing a PBL project respectively. The researchers looked for very specific needs in both the pre- and post- survey responses from the teachers.

5.3.1. Confidence in planning PBL

In the pre-survey responses, teachers cited available examples (7/18) and access to PBL-related resources (5/18) as being their two greatest needs in feeling more comfortable and confident in planning a PBL project, as shown in Table 7. For example, two different teachers expressed their thoughts as the following:

Either seeing one PBL project executed or participating in one (PBL project) in some way would make me feel more confident in planning a PBL project on my own. I just need to see (PBL) examples and read about how to successfully plan and implement a PBL unit. Resources and ideas are needed.

Table 7. Perceived needs for confidence in planning

Emergent theme	Pre-survey (frequency)	Post-survey (frequency)
Perceived needs	Available examples (7)	Just feeling confident (5)
	Access to resources (5)	Peer collaboration (4)
	Having projects modeled (4)	Available examples (3)
	Having experience (4)	Having projects modeled (3)
	Having planning time (2)	Having planning time (2)
	A PBL course (2)	Project management strategies (1)

They also cited experience in planning a PBL project (4/18) combined with the PBL course instructor's feedback as a way of modeling the PBL approach (4/18) would be helpful to build their confidence in planning a PBL project. Table 7 shows another possible way to help increase the comfort and confidence level of teachers regarding planning a PBL project is having sufficient time to plan a PBL project (2/18). Two teachers recognized that the PBL course which they enrolled in would likely help them become confident in planning a PBL project via obtaining needed knowledge and resources (2/18).

As seen in Table 7, upon completion of the course, five teachers (5/18) indicated that they were confident in the planning process of a PBL project, without citing specific needs that may increase their confidence with PBL in the post-survey. Four teachers were more specific in individual needs, citing peer collaboration (4/18) would increase their confidence in planning a PBL project. Three teachers still felt that they needed additional examples of PBL to help them feel more comfortable (3/18). Three teachers also cited that a presence of modeling a PBL project (3/18) would be helpful. Other factors such as having time for planning (2/18) and a need for project management strategies (1/18) were mentioned.

What would be most helpful is if I had another teacher to collaborate with and share the load of creation and build off of one another's ideas (when planning a PBL unit). My biggest problem was determining how much inter-curricular (discipline) information (learning) I could expect from students who were not pursuing STEM fields, and if I could see one (such example) in action, it might help.

According to Table 7, while teachers still listed items needed for overall confidence and comfort in the PBL planning process, the frequencies of the common listed needs (available examples, access to resources, and having project modeled) decreased from the pre-survey. There are also some new needs such as peer collaboration and project management strategies emerged after the students completed the PBL course.

5.3.2. Confidence in implementing PBL

Examination of the teachers' pre-surveys, with respect to confidence in implementing the PBL approach, reflected similar needs described in the planning process of PBL; an echoing call for examples (5/18) and having PBL modeled (4/18), as shown in Table 8.

Table 8. Perceived needs for confidence in implementing

Emergent theme	Pre-survey (Frequency)	Post-survey (Frequency)
Perceived Needs	Available examples (5)	Just feeling confident (6)
	Having projects modeled (4)	Having experience/practice (4)
	Access to resources (3)	Peer collaboration/mentoring (3)
	Having knowledge (3)	School push/support (2)
	Having experience (2)	Having planning time (1)
	Having school support (1)	Teacher autonomy (1)
	Peer collaboration (1)	Consistent classroom time (1)

Other teachers, however, had more specific needs and ideas of how their comfort and confidence with implementations of PBL could be improved. From the pre-survey these issues included: relevant resources (3/18), having knowledge of PBL (3/18), having PBL experience (2/18), having school support, and peer collaboration (1/18). One teacher suggested, "At least speaking to someone who had executed one [PBL project] before would be nice."

In the post-survey, teachers were asked again what could help them feel more confident in the PBL implementation process. Several teachers stated that they were now fully confident and comfortable with implementing PBL (6/18). Other teachers indicated that they needed practice teaching using the PBL

approach (4/18) and a desire to collaborate with others (3/18) “to share experiences or with a peer who has already implemented such a project to talk through anticipated obstacles.” Other factors such as school push and support (2/18), planning time, dedicated classroom time, and teacher autonomy (1/18) would also help teachers feel more comfortable in implementing a PBL approach.

In triangulating the quantitative and qualitative data, most of the participating teachers identified knowledge or skills developed during the PBL course that could ease the PBL planning and implementation process. This finding was confirmed by the quantitative results regarding teachers’ improved knowledge and understanding of essential PBL project design elements as shown in Table 2. However, teachers’ responses also indicated that planning time, school support as shown in Table 6, practice with PBL as shown in Table 5, peer collaboration, and visual or in-person examples and modeling of implementation of a PBL project as shown in Table 7 and Table 8 are essential areas that require more support. In comparing the needs for implementation from the pre- and post-survey, the overall teachers’ needs decreased in terms of knowledge and resources regarding PBL approaches and became more focused as shown in Table 8. The need for resources did not appear in the post-survey, while the need for peer collaboration emerged as a new necessity.

6. DISCUSSION

The overall findings align with prior literature that highlights the importance of professional development in promoting a teacher’s attitude and confidence in the implementation of PBL [36], [44]. There was a significant difference between the teachers’ perceived ability to plan and implement a PBL unit at the beginning and end of the course. Participants were also more confident in their abilities, and expressed greater optimism towards PBL as a pedagogical shift in their practice. Additionally, participants understood the foundational PBL components better at the end of the PBL course, which may have contributed to their increased confidence in PBL. By strengthening teachers’ perceived ability in using PBL, we hope to enable teachers to apply their newly gained knowledge of PBL, eliminating the notion that such a PBL approach is beyond their ability.

While most of the participants expressed confidence and interest in implementing PBL, they also commented on the challenges that prohibit full PBL realization, including the lack of planning time, the lack of examples and modeling of successful implementation, and the lack of support. The PBL course served as professional development for those enrolled teachers, which may help illustrate how perceptions can be shifted with first-hand knowledge. In our study, participating teachers identified specific experiences, such as the course being modeled on a PBL approach, which could prepare them to plan and implement PBL in their own classrooms. This emphasis on modeling, and relevant instructional materials, mirror the conditions in which the students in one’s own classroom may experience this model-motivating a successful shift toward the PBL pedagogical model for teachers [37]. Indeed, upon completion of the course, participating teachers noted that they were especially excited for their own students, perhaps projecting their own experiences.

This study identified the lack of PBL modeling as being an ongoing challenge for the participating teachers. Kramer [6] alluded to this as well, identifying that teachers struggle to apply PBL training in their own practice, which means there are no further opportunities to refine, reflect, and initiate continued PBL efforts. Teachers in the PBL course were able to work with their peers and the course instructor on planning their PBL units. However, essential elements, such as implementing the PBL unit within their classrooms and having continued support after the course ended which could improve the success of PBL implementation in the long-term, were missing [37]. The success of an individual teacher’s implementation is often dependent on the environment or culture of their institution, as evidenced by the participants’ concerns expressed in this study. Effective PBL implementation often requires a school-wide initiative to sustain teachers’ pedagogical shift [17]. On a smaller scale, peer collaboration and mentoring may be an effective way to provide the kind of implementation support from schools, which the teachers expressed in this study.

As expected, some of the challenges identified in the pre-survey decreased or disappeared in the post-survey and post-semester reflections. Teachers gained confidence over obstacles such as a lack of confidence and the access to resources regarding PBL implementation as shown in Table 4. In the post-survey, the top challenge was the lack of implementation experience with PBL. While the PBL course provided teachers the necessary knowledge, teachers still needed the opportunity to apply PBL in their classrooms. This finding is also consistent with prior research that training in PBL alone is insufficient to help teachers implement PBL [6]. Challenges identified in the teachers’ post-semester reflections included obstacles related to specific items within a school’s culture. This aspect connects to prior literature citing similar issues, such as lacking support for implementation and curricular concerns [31], [32]. Teachers reported planning time as being a small concern in the pre- and post-survey. However, the lack of planning time was the most dominant concern within the post-semester reflections as shown in Table 6. This may

indicate that the teachers were more likely to focus on the future and their independent efforts to create PBL units. In short, the PBL course in this study might have been successful in educating teachers in how to design and implement PBL based on research, practice and professional development literature. Additionally, the PBL course may have spurred teachers in examining some practical, immediate applications-and the potential struggles that could occur when creating this learning environment.

In looking to resolve some of these identified challenges, we recommend promoting peer collaboration and conversations between and among teachers. Additionally, connecting teachers with active PBL practitioners would help facilitate the discussion of the common challenges, including a lack of planning time and lack of modeling. Connecting teachers with active PBL practitioners provides a community of support and is a practical solution to assist teachers in taking the steps in PBL implementation [37]. With a large enough network, teachers could visit nearby classrooms to observe implementations firsthand. Additionally, issues surrounding modeling can be tackled through the use of video examples. This would allow teachers to view a recorded lesson on their own time and at a location of their choosing. Providing video examples would also ensure that those who cannot connect with another teacher in their area would have the opportunity to view PBL in action. Furthermore, some teachers reported that having access to PBL resources would be helpful. An organized document or website on PBL for teachers could act as a handbook for teachers as a go-to reference when they begin the PBL implementation process, or future iterations of planning PBL projects.

Despite perceived challenges and obstacles, teachers were optimistic that PBL had worth, a place within the classroom, and that a formal PBL course had helped prepare them to move forward. Teachers voiced positive outcomes and indicated optimistic viewpoints in terms of planning and implementing their PBL units. Some teachers indicated that they were looking forward to implementing PBL and they felt that their experience with PBL enhanced their positive feelings toward teaching. The teachers' reported confidence and optimism found within this study indicate that a formal PBL course could improve both teachers' self-efficacy and understanding of PBL, ultimately making them more likely to implement PBL in the future.

Overall, research on PBL still demands attention for the improvement of PBL facilitation and its practical application. This study contributes to PBL literature in examining a formal graduate level PBL course and the benefits of such as a means to provide a sustained, immersed and modeled professional development experience for practicing teachers. It also helps the field understand the challenges and emerging needs such as peer collaboration for a wide adoption of PBL in classrooms. Future research is encouraged in examining the benefits of modeling the PBL approach to teachers as a part of PD. Additionally, research into the amount of planning time required for a PBL approach versus traditional models of instruction, and the PBL professional development at a team or institutional level in the form of peer collaboration would be beneficial to the field.

7. CONCLUSION

The study found that there was a significant difference between the teachers' perceived ability to plan and implement a PBL unit at the beginning and end of the course. Participants were also more confident in their abilities, and expressed greater optimism towards PBL as a pedagogical shift in their practice. Additionally, participants understood the foundational PBL components better at the end of the PBL course, which may have contributed to their increased confidence in PBL.

Limitations of this study largely relate to the relatively small number of participants. However, the mixed methods approach and the triangulation of the quantitative and qualitative data and results have strengthened the findings of the study. For example, issues of concern in the pre-surveys became less prominent in the post-surveys (e.g. confidence in PBL implementation), with the end-of-semester reflections corroborating these changes in sentiment. Both types of data were also mined for emerging challenges, such as the teachers' lack of implementation experience or concerns over the lack of support for PBL in their respective teaching environments. Overall, the use of the mixed methods approach provided more insight to the concerns and challenges faced by the teachers.

Lastly, an instructional strategy as complex and context-specific as PBL requires investment from schools, teachers, students, and their respective communities. As such, the results of this study may reflect the specific culture of the study (i.e., study setting, participants, and professional development methodology). Nevertheless, this study contributes to the field of PBL research by revealing issues surrounding classroom planning and implementation from teachers' perspectives. Additionally, this research contributes in examining the effectiveness of a formal PBL course in promoting teacher confidence and attitude toward the PBL approach.

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