

***Teacher Training for Interdisciplinary Project Based Learning:
A Professional Development Case Study***

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The Asian Conference on Education & International Development 2024
Official Conference Proceedings

Abstract

This research explored Project Based Learning (PBL) teacher training for 13 teachers to prepare them to lead a two-week intensive PBL course for 100 high school students from across mainland China, Hong Kong, and Taiwan. The training program was designed to build sufficient content and pedagogical knowledge to deliver an interdisciplinary program on 21st century leadership linked to a variety of issues including the fourth industrial revolution; the Sustainable Development Goals; transformative computing technologies such as Artificial Intelligence, blockchain, and quantum computing; biotechnology; and the rise of China through organizations such as BRICS and policies such as The Belt and Road Initiative. Content also included leadership, such as the application of agile leadership theory, project management, collaboration protocols, active listening, and public speaking. Due to the interdisciplinary nature of the content, teachers were trained using a PBL approach in which they investigated PBL teaching practices and design concepts in reflective cycles interspaced with taking the role of students in the program they would later be teaching. Data were collected through observation notes, questionnaires, and post-program surveys that explored the acquisition of content knowledge, pedagogical knowledge, and pedagogical content knowledge. Results suggest strong acquisition of target knowledge, skills, and attitudes. This model may be an effective option for institutions incorporating training in PBL teaching techniques, particularly in situations in which the course content is interdisciplinary and therefore outside teachers' normal subject areas.

Keywords: Project Based Learning, Teacher Training, Professional Development, Curriculum Design, Education for Sustainable Development, Adult Education

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Introduction

Many researchers, policy makers, and educational organizations have noted the need for deep and ongoing education reform to respond to the rapidly changing technological, social, environmental, and economic realities facing humanity (UNESCO, 2020; OECD, 2018; Reimers et al., 2016). These reform initiatives have given rise to several human competency frameworks which serve to describe the kinds of capacities people should attain and therefore that education systems should backward design from, such as Education for Sustainable Development competencies (Reickman, 2018) and the Organization for Economic Co-operation and Development's (OECD, 2018) Education 2030 competencies. These competency frameworks are linked to internationally developed targets such as the Sustainable Development Goals (SDGs), which are designed to provide a roadmap for mitigating the most pressing problems we face as a species as well as to help people seize opportunities and maximize human potential through the provision of clear and measurable targets on seventeen different dimensions relating to poverty, inclusion, innovation, the environment, human security, and peace and governance (UNESCO, 2020).

Conceptualizing the pedagogy for the attainment of these competencies is complex as they go well beyond targeting disciplinary knowledge and include other types of knowledge such as epistemological and interdisciplinary, a wide range of skills such as metacognitive and socio-emotional, and finally attitudes and dispositions relating to community and citizenship in contexts ranging from local to global that are all to be combined into real world action (OECD, 2018). Pedagogies for this kind of education are typically described with terms such as learner-centred, action-oriented, and transformative (Reickman, 2018). Bourn (2021) also notes the importance of utilizing a pedagogy of hope situated within important current issues so that students and teachers feel their education is providing the knowledge, skills, and attitudes to effectively address the problems they face.

Project-Based Learning (PBL) is increasingly recognized as a means to support student acquisition of these competencies because it combines the use and assessment of knowledge, skills, values, and attitudes directed toward real-world problem solving (UNESCO, 2020). However, the use of PBL does not guarantee efficient learning and care must be taken in the design to ensure academic content knowledge acquisition is maintained and optimized (McDowell, 2017). In addition to designing for effective acquisition of traditional academic competencies, PBL design processes also need to continue to be updated to keep abreast of emerging competencies such as increased pressure for emphasizing sustainability competencies and digital competencies, particularly in a post-generative AI world (Hazard, 2023).

Problem-based learning is one of five interrelated types of project-based learning described by Larmer et al. (2015), which may also include meeting design challenges; investigating abstract questions; conducting research; and developing evidence-based positions on issues. Using PBL as a model for preservice and professional development has been noted as particularly effective across many professions' continuing education in part due to the application of knowledge, skills, problem solving, and other professionally relevant abilities in authentic contexts of learning (Salinitri et al., 2015).

Milner and Scholkman (2023) note that the current requirements for teachers to deliver 21st century education through pedagogies such as PBL suggest that problem-based/project-based teacher training has merit due to its unique characteristics for modelling transformative

education for teachers so they can later guide students through similar experiences. Although Milner and Scholkman (2023) are primarily concerned with teacher-driven research utilizing a problem based approach, this same line of thinking about modelling 21st century education may be extended to training in PBL teaching and learning practices, such as when developing skills by putting trainees in the role of students who undergo programming almost identical to what they will eventually deliver so they can experience the project workflow, learning activities, and assessments from the viewpoint of a student while simultaneously being able to reflect on how more advanced teachers facilitate the programming. Similar training models have previously been used in other professions (Wuenshell et al., 2007).

Method

PCK Framework

The purpose of this research was to gain understanding into effective training for PBL teaching and learning practices rather than curriculum design. The PCK framework (Shulman, 1986) provides a simple way to describe the different types of knowledge and skills teachers need to be effective. Content Knowledge (CK) is the disciplinary or interdisciplinary knowledge and skills that students are meant to acquire through their study. Examples include verb conjugation in language studies and the hydrologic cycle in environmental studies. Pedagogical Knowledge (PK) includes the learning theory and teaching and learning techniques that are used to teach effectively, regardless of the discipline being taught. Examples include direct instruction, the use of jigsaws, and assessment design. Pedagogical Content Knowledge (PCK) is pedagogical knowledge specific to teaching a particular content area, such as common areas of student misunderstanding during a particular course in world history.

In this instance there was a need to build a high level of teacher competence in order to effectively deliver a 60 contact hour intensive PBL course for 100 high schools students between the ages of 15 and 18 from across mainland China, Hong Kong, and Taiwan. The students' academic backgrounds were unknown as it was a summer course with students originating from a wide variety of cities and institutions. As the content of the program was not standard curricula for either the teachers or students, the teacher trainees needed to learn the PK relating to PBL, but also the necessary CK and PCK in a relatively short period of time (approximately 36 content hours).

Research Question

What understandings regarding teacher training for PBL lesson facilitation can be uncovered using a train-the-trainer model that incorporates role-play as students and project-based inquiry to acquire the necessary content, pedagogical, and pedagogical-content knowledge for effective interdisciplinary program delivery?

Research Participants and Location

Thirteen teachers were commissioned as instructors. Participation in the research was voluntary and data anonymized. Pseudonyms were assigned to data sets and are utilized throughout this research. The teachers ranged in experience from fully qualified to pre-service. Regardless of experience level, none of the teachers had training in either PBL teaching and learning techniques or the project content. The research, teacher training, and

student PBL program were conducted at a Chinese bilingual school in Beijing, China. Action research is used by members of a community to solve problems of professional practice and was the model used for this case study (McNiff, 2013).

Design of Teacher Training Experience

The design of the teacher training experience used a dual train-the-trainer and project/problem-based approach. Although PBL program design was not covered in the training, the design of the program was explicitly linked to PBL design frameworks by Larmer et al. (2015) and Hazard (2023) to support connections between theory and practice. Training occurred over six days with six hours training each day divided into three-hour blocks which mirrored workshop activities the students would eventually experience. Before and after the teaching and learning activities, the trainees were reoriented to the overarching research question and used it to drive investigation to deepen their understanding of PBL pedagogy. Throughout the process, trainees were invited to give feedback for program improvement.

Overview of Training Content Being Researched

Major targets for the training included:

CK

The CK of the training program was interdisciplinary 21st century leadership theory and practice. CK was developed in the phases where the trainees went through an abbreviated version of the student project in the role of students. CK development focused on the following topics and subtopics:

- 1) Tracking megatrends, macro trends, and micro trends as a modern leadership task.
- 2) Leadership, such as application of agile leadership theory and practice, creative thinking protocols, project management training, critical thinking routines, team collaboration and feedback protocols, active listening training, value creation protocols, mindfulness training for emotional intelligence, and public speaking skills.
- 3) The fourth industrial revolution as a megatrend and dynamic context for leadership.
- 4) The Sustainable Development Goals (SDGs) and Environmental, Social, and Governance (ESG) issues in leadership as a megatrend.
- 5) The rise of transformative computing technologies with examples such as Artificial Intelligence (AI), blockchain, the metaverse, and quantum computing as a megatrend.
- 6) The near- and medium-term trajectory of biotechnology with examples such as neural implants, genetic medicine, agricultural technology/genetically modified organisms, 3D printed organs and meat, and tailored pharmaceuticals as a megatrend.
- 7) The rise of China, whether due to its increasing economic, diplomatic, and military power; due to leveraging organizations like BRICS (Brazil, Russia, India, China, South Africa); or due to expansive global policies such as The Belt and Road Initiative, approached as a megatrend.

PK

None of the teachers in training had a background in either PBL curriculum design or teaching and learning practices. PK was developed implicitly when the trainees experienced teaching and learning for the project from the perspective of students and explicitly when

acting in the meta-role of teachers researching PBL. The trainees investigated the following areas of PK using the inquiry question:

What understandings can we, as teachers, come to regarding the effective design and delivery of PBL lessons by trialling a student PBL program ourselves and reflecting on our findings in relation to the PBL literature?

Major areas of PK investigation included:

- 1) Using Sustainable Development Goal 4 set within the wider framework of the SDGs as the overarching context of education.
- 2) Moving from a focus on knowledge acquisition to OECD 2030 competencies (OECD, 2018) for student learning goals.
- 3) Understanding basic PBL design considerations from the Gold Standard PBL design framework (Larmer et al., 2015) and the Global PBL framework (Hazard, 2023) as a means of understanding the program including:
 - A) Authenticity, Contexts of Learning, & Sustainability Vision
 - B) Intellectual Challenge, Depth of Inquiry, & Structure
 - C) Artifacts of Learning & Meaningful Audience
 - D) Student Voice, Choice, Diversity, & Inclusion
 - E) Layers of Collaboration & Assessment Plan
 - F) Technology, Digital Citizenship, & Digital Academic Integrity
 - G) Revision, Reflection, Criticality, and Reflexivity
 - H) Project, School, and Community Impact
- 4) Using big ideas to contextualize links between lessons.
- 5) Utilizing a student inquiry question and facilitating the ongoing generation of subquestions.
- 6) Developing metrics for post-program evaluation and improvement.
- 7) Understanding common workflows for PBL workshops.
- 8) The importance of critique and revision in PBL and how to facilitate these activities.
- 9) Coaching for performance with student teams and individuals.
- 10) Making thinking visible (Ritchhart et al., 2011) in the PBL classroom.
- 11) Understanding active learning and Assessment for Learning in PBL learning activities.
- 12) The importance of reflection and methods of facilitating reflection in PBL classrooms.

PCK

The most important areas of PCK targeted by the training included:

- 1) Knowing common areas of difficulty or misunderstanding in the content, which was developed while engaging with the learning activities in the role of students and then reflecting in the role of teachers after.
- 2) Understanding how core learning activities in each lesson contributed to the course assessments, which was done when acting in the role of students working on the summative assessments and then reflecting afterwards in the role of teachers.
- 3) Clarifying strategies and coaching plans for meeting the assessment success criteria, which was developed when peer-assessing other trainee summative assessments created while in the role of students.

Data Collection and Analysis

Collecting different types of data helps to give a richer analysis as well as improving dependability through triangulation (Creswell, 2012). One source of data (for CK, PK, and PCK) was via researcher observation notes taken during the training and then throughout the execution of the program. A second source of data was obtained using post-training questionnaires (focusing on PK and PCK). Finally, anonymous post-training surveys exploring the acquisition of CK were utilized. Although observational data gathered during the program was the most important indicator of the CK acquisition, the self-reported survey data added value in helping to determine whether the trainees felt confident in their CK and what proportion of the content knowledge they felt they gained from training.

Self-reported survey data first prompted for how much understanding for each content area was preexisting versus what proportion was developed through the training. These questions used the same four-point scale for each content area, which is demonstrated below. A follow up question was then used to check if the trainee felt they had sufficient CK for that area to deliver the program. An example of a survey question and response choices follows:

- 1) How much of the content knowledge relating to *the analysis of micro, macro, and megatrends* did you learn in the training program?
 - 4 – Almost all this content in this area was new to me before training
 - 3 – I learned many new ideas in this content area during training
 - 2 – I learned a few new ideas in this content area during training
 - 1 – I already knew all the content in this area before training
- 2) I felt like I was understood enough of this content area to adequately support the students when delivering the PBL program. Yes/No

Analysis of the qualitative data from observation notes and participant questionnaires was completed using qualitative analysis software. Survey responses were analyzed using descriptive statistics.

Findings/Results

Researcher observation notes indicated the necessary CK was developed to an acceptable level during training. Acquisition was supported by the trainees engaging in the same active learning and feedback opportunities students would be later be asked to do as these required higher order thinking, reflection, and finally synthesis of the CK into learning artifacts that would later be used as assessment exemplars after several rounds of self and peer review. The survey data overwhelmingly demonstrated that the trainees felt prepared to deliver the interdisciplinary CK as of all the responses from instructors indicated that they felt sufficiently prepared, except one instructor who indicated they were not fully prepared to facilitate the target leadership skills of empathy and emotional intelligence, and another who did not feel fully prepared to facilitate the content knowledge relating to biotechnology.

Regarding how much of that preparedness could be attributed to the training program, the four-point scale used ranged from *I already knew all the content in this area before training* (1) to *Almost all the content in this area was new to me before training* (4). The overall mean response for these prompts was 2.94 (*SD* 0.78) indicating that much of the CK used in the

final program delivery was learned in training. These self-reports were supported by researcher observational notes during training. Formative assessment during the discussions and learning activities indicated that most of the content was new to the majority of the trainees.

The content area the participants reported knowing most about before training was China's rise as a global superpower ($M = 2.33$, $SD = 0.81$). Leadership skills in collaboration and coaching ($M = 2.33$, $SD = 1.03$) and the Sustainable Development Goals (SDGs) ($M = 2.66$, $SD = 1.21$) were the next best-known areas of CK before training.

The area the participants knew least (and therefore developed most) in the training, according to self-report, was content knowledge relating to Environmental, Social, and Governance (ESG) ($M = 3.6$, $SD = 0.81$). The two next weakest pre-training areas were CK relating to the analysis of micro, macro, and megatrends ($M = 3.5$, $SD = 0.54$) and CK relating to leadership theory including agile leadership, shifting teams to creative and design mindsets, teams as semi-autonomous value creating units, and the use of design thinking to improve processes and outputs at every level ($M = 3.5$, $SD = 0.54$), all of which were almost completely new for all the trainees.

Results from observation and qualitative data suggest good acquisition of PK relating to PBL teaching and learning, considering the limited number of training hours. PK acquisition was enhanced by experiencing teaching techniques and activities being modelled by experienced instructors and then by reflecting on them, discussing them, and brainstorming for improvement after each phase of the training. Theory and practice were linked routinely to ground the program in the PBL literature. Areas of strength in PK acquisition were for the Global PBL design dimensions (Hazard, 2023) of Artifacts of Learning and Meaningful Audience; Reflection and Revision; and Authenticity and Context of Learning.

For example, Debbie (pseudonym) expressed on her post-training questionnaire that “reflective practices promote deeper learning and allow students to internalize knowledge and skills more effectively. Students can set and adjust learning goals and become more aware of how they learn, what strategies are effective, and where they can improve. We need to avoid treating the reflection and revision as a mere routine or checklist. Encouraging students, especially teenagers, to reflect voluntarily and authentically fosters a deeper understanding of their own learning and personal growth”.

Areas of weakness were in the PBL design dimensions of Criticality & Reflexivity; Impact Analysis; and Sustainability Vision. Although the instructors demonstrated an understanding of the importance of criticality, impact analysis, and sustainability vision, they were not articulated in depth. Reflexivity was misunderstood by several trainees.

Basic PCK was also attained through the process of experiencing the workshops both as a student and in the role of teachers discussing, questioning, and improving the program after each session. Specific areas of strength that were noted included anticipating ideas likely to be challenging or to cause misunderstanding; the application of formative assessment techniques that were designed to match the needs of the unique content; and the ability to coach for the successful completion of the final learning artifacts from the beginning of the program. As an example, Bill (pseudonym) stated “by trialing the program in a group, I can have (sic) the student perspective to spot any potential challenges and issues that might affect the learning. Besides, to experience the authentic and active learning process helped me to

spot the highlights and challenges that student might feel in the program so that I can better prepare to offer support in advance... Also, from an instructor perspective, it reinforces the understanding of the core content, tasks and final artifacts of the program and get me ready for the teaching”.

Discussion

The PBL program the teachers were being trained for was designed to raise awareness of interdisciplinary issues in 21st century leadership that both the students and teachers were almost completely unfamiliar with before training. This may be a slightly unusual situation in that many instructors will engage in PBL training to develop PK but would usually come to that training confident in their subject specialty knowledge. However, as interdisciplinary PBL becomes more common due to international initiatives such as Education for Sustainable Development, disciplinary instructors may find they need to synthesize content across normal subject boundaries more often.

Overall, findings for PK acquisition fit previous works that suggested PBL as a potentially effective for 21st century teacher professional development needs (Milner & Scholkmann, 2023). This case study also documents successful CK, PK, and PCK acquisition for inexperienced teachers using a method of taking the role of the students they will later be teaching in order to learn the course content, understand the teaching and learning techniques, familiarize themselves with assessment success criteria, and then make suggestions for course improvement within a larger investigation of PBL teaching concepts. This fits research utilizing similar PBL training techniques in other professions (Wuenshell et al., 2007).

These findings are significant in that they offer a record of generally effective professional development for PBL teaching and learning. Such professional development is important because PBL has been noted to be an area of pedagogy that is uniquely suited to the development of 21st century competencies sought by many education reform movements (UNESCO, 2020) to meet the current and future needs of both individuals and societies. Effectiveness in professional development efforts is crucial it may help teachers to continually improve and adapt over the course of their careers while teachers without it may stop developing or even regress in effectiveness over time (Kraft & Papay, 2014; Rockoff, 2004).

With regard to teacher development using PBL, Milner and Scholkman (2023, p. 2) note “five principles considered cornerstones of the PBL pedagogical approach: (1) problem identification as the starting point of the PBL process; (2) self-directedness of learning; (3) group collaboration as the dominant way of working; (4) critical reflection as the intended outcome; and (5) variation in the implementation of PBL learning designs”. Although these principles are primarily intended to guide teacher-directed research into their own practice, the results of this case study suggest that, just as with student PBL (Hazard, 2023), PBL for teacher development can vary the depth of inquiry and the amount of structure and support provided depending on the pedagogical goals of the professional development project.

In this case, as the curriculum and PBL teaching methods were a predetermined problem for investigation, the research problem was identified for the teachers in training who then worked together as a team to investigate and solve this problem as the vector of inquiry. They were aided by significant scaffolding supports to guide learning, including direct instruction

for efficient surface, deep, and transfer learning as per McDowell's (2017) recommendations for PBL program design.

Recommendations

Wherever feasible, it would be optimal for teachers who will instruct on PBL courses to be fully trained in PBL curriculum design and be included in the design process from the beginning as a way of improving their pedagogical knowledge, increasing the number of perspectives and creative inputs into the design, and modelling the voice and choice processes that we would like to see more of in PBL classrooms. However, in cases where the design has been completed by interdisciplinary experts or in situations such as when a curriculum has been used before and new teachers are approaching it for the first time, allowing trainees to trial key elements of the program, complete exemplar assessments, and give program improvement feedback appears to be a strong strategy.

Although the project design was centered on 21st century leadership rather than sustainability, sustainability concepts were included as central to the program. However, in future, these concepts could be enriched by enhancing the focus on project impact. Although community impact was discussed in the training phase it was not enacted in the student project well. Because the project was high intensity over a two-week period with students who came from unknown backgrounds and locations, and as it was a first teaching experience for the teachers, it was decided to focus on impact limited to the learning community itself with additional consciousness raising among the social networks of the participants through distribution of their reflective videos. Future iterations would benefit from a stronger impact analysis to see how real-world impact could be increased, both as a program outcome and as a teacher training outcome linked to all elements of PBL curriculum design frameworks.

Another area for improvement in training would be the inclusion of deeper discussion on critical pedagogy and reflexivity to make the underlying ideological underpinnings of the instructors and the context more transparent and open for analysis. This was relatively weak in both the teacher training and the student project work in part due to the tight timelines, but these understandings are considered crucial for effective PBL that is sustainability based (Hazard, 2023) and for quality global education generally (Bourn, 2021).

Including explicit training in visual project management was noted as a highlight by the teachers and by the students who later engaged with the program as well. It was seen as a highly effective transferrable skill that could be used for personal, academic, and professional goals to plan, monitor, and evaluate real-world change projects. The capacity to plan and execute effective real-world action is one of the targets for teacher training that supports teachers in the role of change agents (Bourn, 2016), and the importance of explicit understanding of project management is a hallmark of effective sustainability oriented PBL (Hazard, 2023) and of quality PBL in general (Larmer et al., 2015).

Using PBL as a model for inquiry-driven teacher professional development was one of the areas suggested for future research by Milner and Scholkman (2023). Better synthesis between the theory and practice of teacher research and student-oriented PBL curriculum models could be valuable in future as it has the potential to provide a relatively unified model of inquiry that could be used with only slight variations by administration, teachers, and students in order to develop a variety of projects within a whole school transformation approach. Facilitating such full-scale school transformation through action oriented education

is a key objective in the Education for Sustainable Development literature (Reickman, 2018) and therefore a priority for teachers and researchers interested in supporting that initiative.

Conclusions

This case study found that a project-based approach to investigating PBL teaching combined with immersion into interdisciplinary content in an authentic PBL classroom environment led by experienced teachers was effective overall as a training method. It supported inexperienced teachers with relatively low experience of both the program content and pedagogy to become capable instructors. Finally, by running through the project as students and then giving feedback and making changes to the program after experiencing modelling of the teaching flow, the participants were able to attain sufficient PCK relatively rapidly.

No one system of professional development is suitable for all institutions and contexts (Scribner, 1999). However, providing teacher training opportunities that model an inquiry-based, collaborative classroom in which teachers develop a range of knowledge, skills, and attitudes relating to issues they see as impactful for their own lives can support teachers in providing the same kind of education to their students.

Acknowledgements

We express our appreciation to Dr. Patti Trussler, Aaron Eisberg, Zang Yuanyuan, Dong Ken, Chen Chang, Liang Qifeng, and Wang Yang for their ongoing feedback and support.

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