Interdisciplinary Journal of Problem-Based Learning

Volume 12 | Issue 1 Article 7

Published online: 2-23-2018

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IJPBL is Published in Open Access Format through the Generous Support of the Teaching Academy at Purdue University, the School of Education at Indiana University, and the Jeannine Rainbolt College of Education at the University of Oklahoma.

Recommended Citation

Rillero, P. , & Camposeco, L. (2018). The Iterative Development and Use of an Online Problem-Based Learning Module for Preservice and Inservice Teachers. *Interdisciplinary Journal of Problem-Based Learning, 12*(1).
Available at: https://doi.org/10.7771/1541-5015.1729

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Cover Page Footnote

Acknowledgments: This work was supported in part by a U.S. Department of Education Teacher Quality Partnership (TQP) grant titled “Integrating STEM, Literacy, and Language to Prepare All Teachers to Teach English Language Learners.”

This voices from the field is available in Interdisciplinary Journal of Problem-Based Learning: https://docs.lib.purdue.edu/ijpbl/vol12/iss1/7

The Interdisciplinary Journal of Problem-based Learning

VOICES FROM THE FIELD

The Iterative Development and Use of an Online Problem-Based Learning Module for Preservice and Inservice Teachers

Peter Rillero and Laurie Camposeco (Arizona State University)

Abstract

Teachers' problem-based learning knowledge, abilities, and attitudes are important factors in successful K–12 PBL implementations. This article describes the development and use of a free, online module entitled *Design a Problem-Based Learning Experience.* The module production, aligned with theories of andragogy, was a partnership between the recipients of a grant using PBL to enhance English language learner education and the Sanford Inspire Program. A multistage evaluation design was used in the iterative process of module creation. Starting with an initial white paper, the module's conceptualization, development, pilot testing, and refinement are described, along with the current use statistics. The URL for the new, easier to access location for the module is provided, along with suggestions for its use in teacher education.

Keywords: problem-based learning, teacher education, preservice teachers, online learning, assessment, inservice education

Introduction and Objectives

Problem-based learning (PBL) imbues teachers and students with different roles in the instructional process (Bridges, 1992). Teachers who understand the philosophy and methods of this approach have the foundation to create and facilitate successful PBL environments, making teacher education an important part of PBL implementation. The objectives of this paper are to describe (a) the iterative process of creating a PBL module for preservice and inservice teachers, (b) features of this module, (c) statistics on module use, and (d) how the module can be part of a comprehensive teacher education program. The freely available module was created with the goals of deepening K–12 teachers' understandings of PBL and, in combination with other educative experiences, helping teachers effectively implement the approach.

Perspectives and Theoretical Framework

Problem-Based Learning: From Universities to Grades K–12

With roots in medical education over 50 years ago and permeation throughout professional education, well-researched university-level PBL provides insights into PBL benefits and improvements (Jerzembek & Murphy, 2013). The perspicuous links from activities of professional practice to university-level PBL experiences provide relevancy and meaningfulness for future professionals (Biggs & Tang, 2007). While the results of PBL for short-term knowledge are mixed (Davidson & Major, 2014), a meta-synthesis of meta-analyses found that PBL results were superior to traditional methods for long-term knowledge retention, skill development, and student and instructor satisfaction (Strobel & van Barneveld, 2009). A legion of problems at appropriate challenge levels have been developed that use and develop the nascent skill sets of developing professionals.

The long use, positive research results, and evolved methodologies make PBL widely accepted in professional education (Da Silva & Dennick, 2010; Dolmans, De Grave, Wolfhagen, & van der Vleuten, 2005). While the diffusion of the approach in K–12 classrooms has been slow, new standards in mathematics and science education may catalyze greater use (Rillero, Koerner, Jimenez-Silva, Merritt, & Farr, 2017). To be sure, similarities exist between K–12 and university-level PBL, such as the student-centered and collaborative approaches, and the learning journey embarks

http://dx.doi.org/10.7771/1541-5015.1729

as an interesting problem (Boud & Feletti, 1997). There are, however, differences: K–12 students are children, while university students are adults or emerging adults. Children will have different life paths leading to diverse professions, so K–12 problems do not have a profession to guide the content and skill development. Finally, resource shortages are often cited as barriers to inquiry work in K–12 settings (Haury & Rillero, 1994). These factors may make PBL implementation more challenging at K–12 than at university levels.

K–12 PBL methodologies have not been as well researched as those at university levels (Horak & Galluzzo, 2017, Jerzembek & Murphy, 2013; Maxwell, Mergendoller, & Bellisimo, 2005). Yet systematic reviews and meta-analyses of research have shown similarities to the results of university-level analyses. For grades 6 to 12, Jensen's (2015) meta-analysis indicated that PBL-instructed students outperformed traditional students on content knowledge and skill assessments. Concerning academic achievement and long-term retention of knowledge, a meta-analysis revealed higher scores for PBL students than traditional curriculum students in Turkish primary and secondary schools (Batdi, 2014). A recent K–8 PBL systematic literature review (Merritt, Lee, Rillero, & Kinach, 2017), determined that math and science education studies meeting quasi-experimental design standards reported significant differences favoring the PBL group on 87.5% of the academic achievement-dependent variables. Further, investigations of attitudes revealed significant differences favoring the treatment groups.

Considerations of literacy in a subject area extend beyond the classroom to knowledge and skills that are useful—especially later in life. PBL may have benefits for these long-term perspectives. In a recent study comparing PBL with direct instruction in a fifth-grade Indonesian classroom, the PBL group had statistically significant improvements over the direct instruction group on a measure of mathematical literacy (Firdaus, Wahyudin, & Herman, 2017).

Despite some promising results, more research on PBL in K–12 classrooms needs to be done. A key aspect of any classroom implementation of PBL is to help teachers acquire the necessary attitudes, knowledge, and skills.

Teacher Understanding of PBL

As PBL was first implemented, it was recognized that it would change the roles and responsibilities of students and teachers (Bridges, 1992). An important determinant of successful PBL is the knowledge teachers have and their abilities to implement the approach (Maxwell et al., 2005). In their study of PBL, Yukhymenko, Brown, Lawless, Brodowinska, and Mullin (2014) concluded that experienced PBL teachers create

> a positive classroom environment by facilitating students' growth and suggesting how students may improve. Students become increasingly independent in self-directed collaborative learning while sharing ideas and resources, transferring knowledge actively across domains, and searching for solutions to the given problem. (Yukhymenko et al., 2014, p. 106)

For students to be successful in PBL "teachers must be intentional in the design of the learning environment and the enactment of support strategies" (English & Kitsantas, 2013, p. 130). Teachers, however, may have difficulty finding the balance between supporting students while moving away from direct instruction (Pepper, 2009). Offering different levels of support and choice can be intimidating for both new and experienced teachers (Strevy, 2014). In a recent study of a PBL implementation in a college of education, instructors were reluctant to provide direct teaching and even guidance because of an assumption that students should be independent learners (Koh & Tan, 2016). This also affected students; some thought they should not ask the instructor for assistance.

An additional challenge in teacher education is that inservice and preservice teachers may not have experienced PBL as learners and might not have PBL implementers to observe (Lehman, George, Buchanan, & Rush, 2006; Strevy, 2014). Further, PBL has many components. Conclusions from a narrative literature review made the following suggestions for teacher training: (a) scaffolding guides for student learning, (b) using age-appropriate self-monitoring and self-reflection tools, (c) paying attention to low-achieving students so they are not left behind, (d) paying attention to student preferences, and (e) changing their roles from providers of information to coaches (Jerzembek & Murphy, 2013).

Useful categories for teacher characteristics for effective PBL implementation include skills, attitudes, and knowledge (Pourshafie & Murray-Harvey, 2013). After preservice teachers experienced PBL as learners, they found that they recognized the need for a shift in attitude about the role of the teacher and that the shifting attitude would influence both knowledge and skills of PBL. The preservice teachers reported developing skills, with the most challenging skills being "creating a space" and "facilitator's input." The process of being able to hold back teacher input is important for creating a space for student learning. The preservice teachers' statements about knowledge indicated a range of areas where they could see the importance of knowledge for PBL implementation, such as knowing (a) the curriculum and (b) what students know (Pourshafie & Murray-Harvey, 2013).

Theoretical Model

Although the goals are related to pedagogy, this work for preservice and inservice teachers recognizes that as adults, they have different needs and ways of learning than the

children they will teach. In the theory of andragogy, Knowles (1980) describes the importance of self-directedness and autonomous learning. An online module that adults explore on their own schedule and at their own pace can facilitate self-directed learning (McCarthy, 2014). Another key component of andragogy is seeking to immediately apply learning (Knowles, 1980). The self-pacing of online modules with prompts for application help address this adult need.

Online Modules in Teacher Education

A research-to-practice gap exists across many areas in the field of education (Finelli, Daly, & Richardson, 2014; Greenwood & Maheady, 2001; Williams & Coles, 2007). While education research is being conducted, it is not frequently "used to guide practitioners towards methods and procedures most likely to yield positive results" (Jones, 2009, p. 101). Many preservice teachers finish their preparation programs without learning how to access research articles, let alone translate research into practice (Greenwood & Maheady, 2001). Even experienced teachers may be unsure of how to access and apply education research (Cook & Cook, 2004; Kennedy, 1997). This gap does not just exist in K–12 classrooms but can extend into the teaching practices of college and university faculty (Finelli et al., 2014). In one moment teacher educators may speak about some sort of research-based practice, but in the next moment abandon that same practice when it comes to how they instruct their students (Finelli et al., 2014).

Online, interactive modules are one type of resource that can help bridge the research-to-practice gap and help learners develop mindsets, knowledge, and skills around a particular topic. The Sanford Inspire Program has developed on-demand modules since 2014 (Simmons, Villa, & Borden, 2016). They offer educators a very narrowly focused learning experience with relevant and synthesized research in 60 minutes or less.

Methods

A multistage evaluation design (Creswell, 2014) was used in the iterations of the module development. These methods "are used when researchers seek to evaluate the impact of a program or project" (Creswell, 2014, p. 550). Advocates of the approach stress the need for intersection of mixed methods, considerations from a variety of stakeholders, and addressing multiple facets of an intervention (Plano Clark & Ivankova, 2016). The steps of the development of the module, internal evaluation and the stages, and module refinement were documented with the approximate number of hours spent on major tasks provided. The work times for each step are provided for planning and budgeting purposes in the development of other modules or similar education materials.

A PBL Module for Teacher Education

Partnering for Development

A U.S. Department of Education grant ("Integrating STEM, Literacy, and Language to Prepare All Teachers to Teach English Language Learners") was received to transform our teachers college for the challenges of preparing future teachers to work with English language learners and implement PBL through an approach called Problem-Based Enhanced Language Learning (PBELL) (Rillero et al., 2017). The grant team, led by the lead author, worked with the Sanford Inspire Program (SIP) team, led by the second author as lead designer, to develop a PBL module entitled *Design a Problem-Based Learning Experience.* This collaboration led to a product that could be used by preservice and inservice teachers as well as teacher educators as a part of a comprehensive strategy to make problem-based learning a reality in the classroom. The remainder of this article describes the development and use of the module.

White Paper on Components of PBL

It was important to agree upon what we mean by PBL. White papers are documents that were first used by the British government in the early 20th century to describe proposals for new policies and procedures (Pugsley, 2013). We chose the format of a white paper to describe the characteristics of PBL and to have an overarching definition. The development used discussions and literature reviews, and was disseminated to outside experts, throughout our college, and to interested groups within our university (Rillero, 2015).

The definition of PBL in the white paper is: *Problem-based learning is an instructional approach where learners grapple with meaningful problems and collaboratively work toward their resolution.* The following nine components were described in the document: Meaningful Problem, Problem First, Solution Seeking, Collaborative Work, Solution Sharing, Problem Guides the Learning Approach, Student Centered, Focused Outcomes, and Evaluation. The white paper was circulated to all faculty within our college, to other university faculty, and to stakeholders of the grant. It was meant to promote dialogue and be a flexible document that would be changed as part of discussions. There were, however, no proponents of change for the white paper.

The Development and Testing of the Module

PBL Module Development

The overall steps in the creation of the module are presented in Figure 1. As with the creation of other modules, in each step of the design process, the lead designer's work is reviewed by managers or people doing similar work, critical feedback is given,

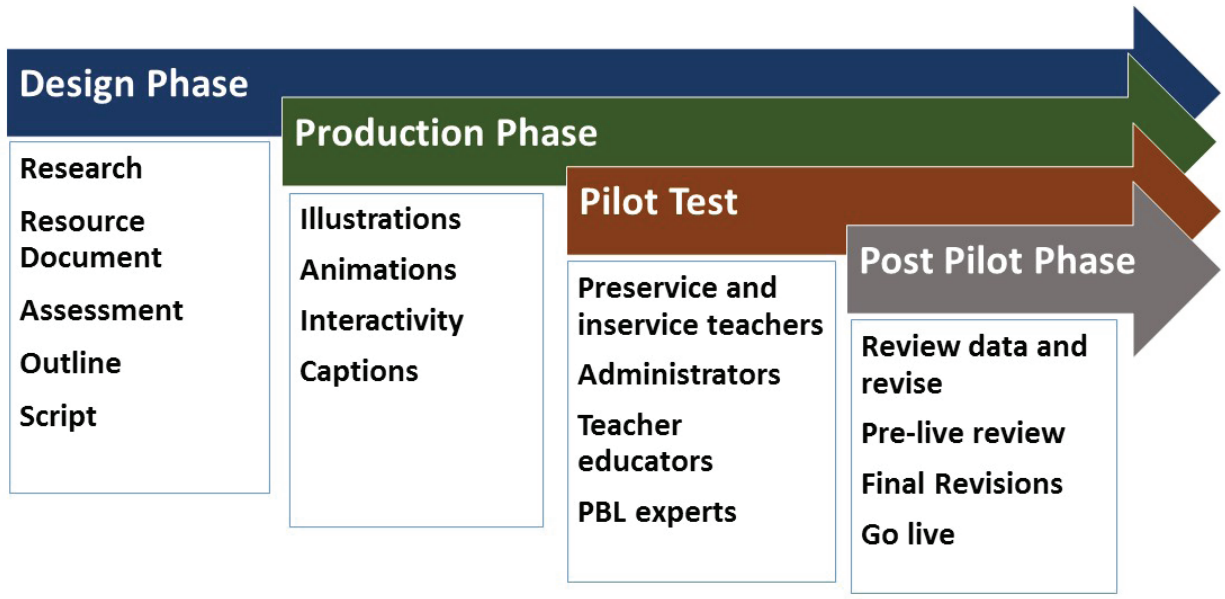

Figure 1. The overall steps in the design, building, and testing of the module.

and revisions are made. For this module, additional touchpoints between the lead designer and the PBELL team were developed, providing opportunities throughout the process for the PBELL team to provide suggestions, ideas, and considerations.

The Design Phase

A literature review led to the production of a research summary (40 hours of work time), leading to the creation of the module objectives and bibliography. The research summary, bibliography, and objectives were reviewed by another designer as well as the PBELL team. Language in the objectives was adjusted based on feedback.

Clear objectives led to the six-question assessment (eight hours). Question formats include multiple choice, select all that apply, and scenario-based questions to assess the user's understanding of skills, knowledge, and mindsets learned during the module.

The objectives and conceptualization of the content also led to the development of the resource document (eight hours), which described required mindsets for PBL, guiding questions, and the nine salient PBL components described in the white paper. Supplemental materials included a guide for brainstorming and a lesson plan template. A glossary of vocabulary was also created.

Module resources, supplements, and assessments were then sent for review and feedback. The assessment feedback focused on the rigor of questions and took about four hours to revise. The module resource revisions (six hours) were on language and grammar.

An outline for the module was developed (10 hours) that included sequencing of content and interactivity. Once the PBELL team and a SIP member reviewed this document, the lead designer applied feedback and began writing the script for the module (16 hours). This included suggestions for graphics, directions for interactive components, and developing text for spoken parts of the module.

The script was sent for review. The lead designer revised the script (eight hours) based on feedback from the PBELL team and a SIP member. The next iteration was then sent to three SIP managers for additional feedback. After revisions, there were two read-throughs with each team, where the entire script was read out loud and a note-taker recorded feedback.

Upon completion of the read-through edits, a teaching and learning specialist manager copyedited the script, the audio files were recorded, and the module moved to the production team.

The Production Phase

Graphics creation for this module took approximately 36 hours. The graphics were internally reviewed by the SIP team, and about eight hours were spent revising them based on feedback.

The instructional designer built the interactive learning experience using the program Articulate Storyline II, and the process took approximately 24 hours. Interactivity and on-screen action were then tested for functionality. Once the functionality testing was completed, the lead designer tested the module to ensure accuracy of content as well as the functionality of on-screen actions including checks for understanding. This review took approximately three hours. The instructional designer then applied any feedback and the module was ready to go into pilot testing.

Pilot Testing

Before publication, the module was pilot tested with five preservice teachers, four teacher educators, six inservice teachers, and three inservice administrators. Here is a recap of some data captured during pilot testing:

- The module took an average of 31–60 minutes to complete.
- All 18 people felt that the module effectively met its objectives.
- Fifteen people felt that the module met their expectations.

Post-Pilot Phase

The design team then analyzed feedback provided by plot testers and applied it to improve the quality of the module. As part of post-pilot edits, the following are examples of changes that were made to the module:

- Implemented wording-change suggestions from subject-matter experts.
- Revised explanations to be more clear in Chapter 5.

Based on suggestions by both teams, supplemental documents were created. One provides space for users to brainstorm a PBL experience that corresponds with each step. The second document is a blank lesson plan template that follows the same format as the *Bears on a Boat* (Rillero, Thibault, Merritt, & Jimenez-Silva, in press) lesson plan users saw in the module. In this lesson, students are challenged to use aluminum foil to make boats for plastic counting bears. The module was made available to the public in March 2016.

Description of the Module: The User Experience

Here is an overview of *Design a Problem-Based Learning Experience*. On the homepage (shown in Figure 2, see next page) users are able to view module objectives and see several resources.

The content of the module is divided into the following chapters:

1. Introduction: Users are introduced to a definition, required mindsets, and benefits of PBL.
2. Designing an Experience: In this chapter, users learn the three steps and corresponding criterion for each.
3. Tips for Getting Started: Users can view video of subject-matter experts explaining different tips for planning their first problem-based learning experience.
4. *Bears on a Boat*: Users view an annotated exemplar lesson plan that explains how each criterion and step are met.
5. Evaluate a PBL Experience: Users have the choice of either evaluating a PBL experience or proceeding to the conclusion.

Once users complete the chapters, they are directed to take a six-question assessment. To receive a certificate of completion, users must receive 100% on the quiz. They may retake the quiz as many times as they need. The resource document for this module includes a description of important mindsets associated with PBL. It also outlines each step and provides an in-depth explanation of the criteria associated with each step.

Module in Use Data

The module was accessible from its release in March 2016 until July 2017 on one of our college's learning resource pages. After an initial registration, the module can be used by anyone in the world. The local hosting and limited advertising made the primary users those with affiliations to our college or university.

The data for the module use were accessed by the learning management system Moodle and downloaded as a CSV formatted file, accessed with Microsoft Excel. The data reported are from the release to June 1, 2017. There were 421 people who registered to use the module. For the registrants with geographical data, the participants were from the following three countries: United States (340), Ireland (55), and Italy (1). The U.S. registrants came from 12 states (Arizona, California, Florida, Kansas, Louisiana, New Jersey, New York, Oregon, South Dakota, Texas, Washington, and Wisconsin) and the District of Columbia, with Arizona being the state with the most registrants (282). There was no special recruitment of participants to use the module. Some of our college courses required students to use the module; other participants may have found the module from Internet searches or from recommendations by colleagues.

Of the 421 registrants, 286 people fully completed the module, which is indicated by a perfect score on the assessment section. This is a completion rate of 67.93%. Since the module was made available online, the average number of completions per month has been 20.43.

The average quiz score was 7.27 out of 10. Participants have multiple chances to complete the quiz. There were 1,111 quiz attempts. For people who took the quiz at least once, the average number of quiz attempts was 3.06.

Table 1 (see next page) shows the individual results for each quiz item and a brief topic associated with that item. Items 6, 5, and 3 were the most difficult items to answer correctly, while items 2, 3, and 4 were the least difficult. The most difficult item to answer was number 6 (in red in the table), which related to assessment of objectives in PBL. The easiest item was number 2 (in blue in the table), which related to the benefits of PBL.

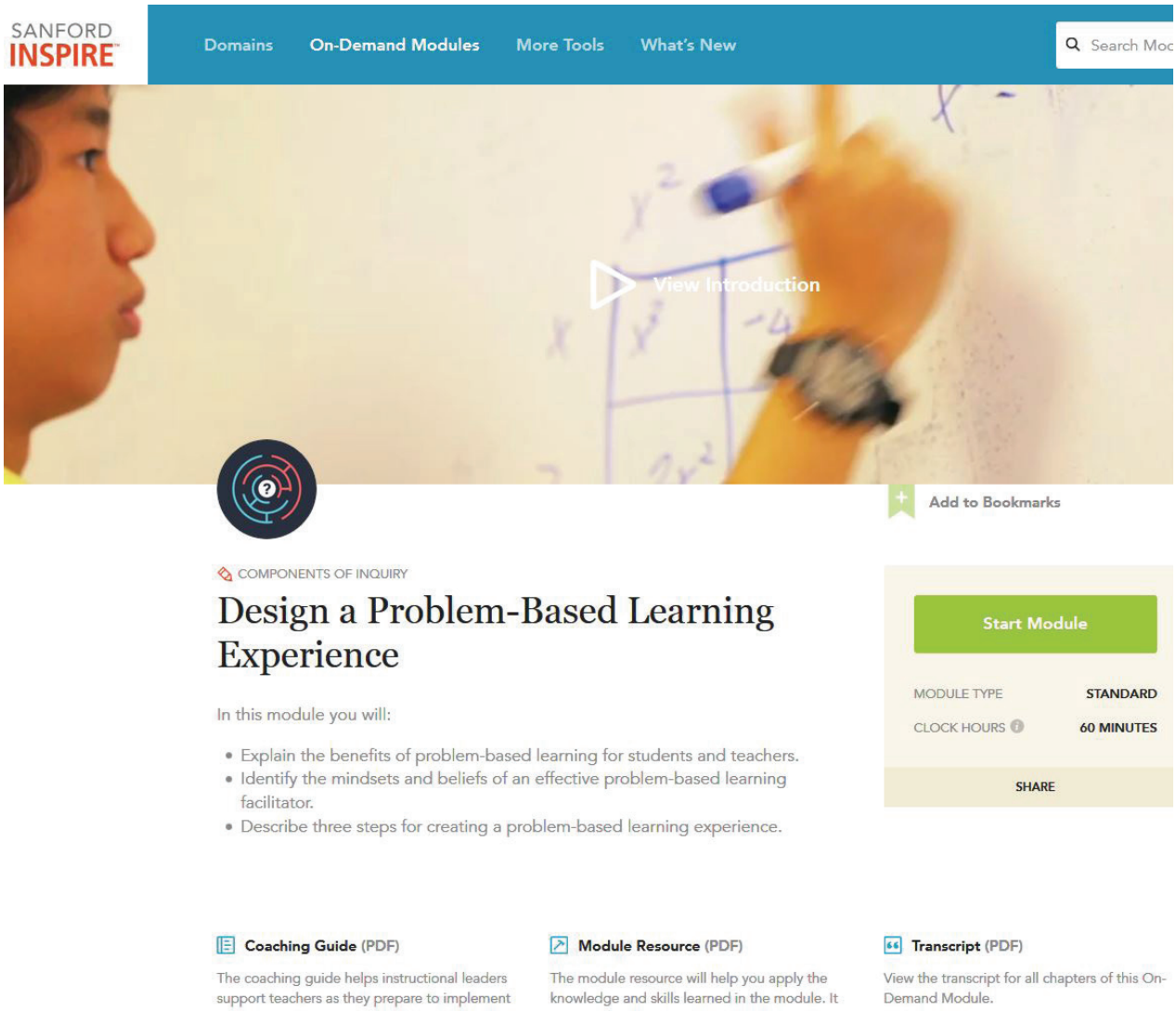

Figure 2. The opening screen of the PBL module.

Quiz Item	Answer Attempts	Average Score	Item Topic
1	395	1.10	Getting students ready for PBL
2	89	1.57	Benefits of PBL
3	201	1.40	Challenges in PBL implementation
4	342	1.18	The problem comes first in PBL
5	414	1.07	Solution sharing in PBL
6	460	1.00	Evaluation and PBL

Table 1 . Indicators of Quiz Item Difficulty

Discussion

As expected, the module use was greatest in the state of Arizona, where we are located. Of all the registrants, 67.93% completed the course and assessment and earned the certificate. In comparison to Massive Open Online Courses (MOOCs), this is a high completion rate. In a recent study of MOOCs, only an average of 5% of registered students completed the courses to obtain certificates (Evans, Baker, & Dee, 2016). The greater completion levels may be because the module is shorter than a course. Students may also have greater motivation to complete the module if, for example, it is a course assignment.

Although the focus of the module was on PBL and designing PBL experiences, the learning was guided in the module, and wasn't an example of PBL as an instructional tool. Nevertheless, with andragogy as an important framework, self-regulated learning, which is also a key component of PBL (English & Kinsantas, 2013), was a component of the module. Self-pacing, prompts for thought and application, may have also promoted relatively high levels of achievement.

The assessment in the module is designed to be both an evaluation and a learning tool. The assessment can be retaken until a perfect score is achieved, which is necessary to obtain the certificate. Thus, as a learning tool the module promotes mastery learning with opportunities for rethinking questions and answers. The assessment item on evaluation and PBL had the most answer attempts, which aligns with a key challenge of PBL; the multiple outcomes deepen the challenge of student evaluation (Rico & Ertmer, 2015).

The module creation process is time consuming and thus expensive. The multistage evaluation design was used to inform and improve upon the iterations. The development, circulation, and discussions of a white paper on our definition of PBL and its most essential components provided a strong foundation for the subsequent work. The work was informed and improved by reviews by people who have deep knowledge of both education and module creation. The reviewers were colleagues and team managers of SIP and all the faculty and staff of PBELL. Throughout the development process small tweaks, such as wording choice or in sequencing, greatly improved the published module. The pilot-test feedback came from inservice teachers, preservice teachers, teacher educators, and education administrators. Decisions to revise based upon the pilot test were discussed at a two-hour post-pilot meeting that included the lead designer, graphic designer, and instructional designer team leader. As with other complex undertakings, the stages in the development build upon each other, making early feedback critical in the process.

To be sure, a limitation of this study is that the data that informed our iterations for our module are specific to our project. Nevertheless, the following are two aspects of this work that can be useful for other projects and programs: (a) the steps and feedback incorporated during the module development and (b) the actual module itself. Future research should address the effectiveness of the module in different contexts and with different groups of users. Design-based research with attention to contexts may provide insights in the role of the module in lessening the research-to-practice gap (Design-Based Research Collective, 2003; Vanderlinde & van Braak, 2010). Preservice and inservice teacher beliefs, knowledge, and skill development can be studied for module use for teaching in a variety of different contexts including content areas, types of classrooms (such as regular, STEM, and special education), school cultures, and schools with different levels of resources. As Jerzembek and Murphy (2013) suggest, there are many teacher skills that need to be developed in PBL. Research is needed on the supports beyond the module that will help new-to-PBL teachers develop abilities to create scaffolds, know when to use scaffolds and when to let students work independently, and move further toward the role of a coach rather than a provider of information.

While knowledge and skills are first steps, research on teacher beliefs about PBL is of particular importance because teacher beliefs may impact future instruction more than teacher knowledge (Opdenakker & Van Damme, 2006; Pajares, 1992). The module could contribute to broader collaborative professional development by serving as a shared foundation for discussions and development of materials. Key aspects of teacher professional development include pedagogical focus and experiences situated in a school's context (Liao, Ottenbreit-Leftwich, Karlin, Glazewski, & Brush, 2017). While the module can help address teacher needs and pedagogical growth, teacher-led professional development also must acknowledge learning as an active, social process that requires collaborative opportunities working in school-specific contexts (Patton, Parker, & Tannehill, 2015).

Suggestions for Use of the Module

The module is now available at the following website that is independent of our college: http://sanfordinspireprogram.org. The former site required registration at our college's Professional Learning Library prior to accessing the module. The new URL provides a direct link to the modules with rapid registration and easy access. The goals are to have greater use of the modules from diverse regions of the world.

The module is a potential tool in many preservice and inservice teacher education programs that view PBL as an

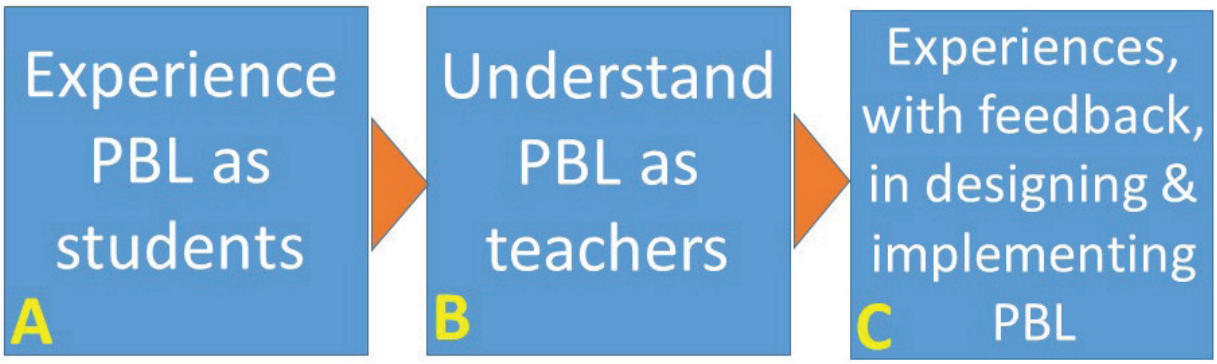

Figure 3. The phases of PBL experiences for preservice teachers.

important method. Learners register for the module, conduct the interactions, and upon successful completion of the assessment, are awarded a Professional Development Certificate that can be used as proof of completion. The module is meant to contribute to a comprehensive approach to understanding and being able to design PBL experiences.

The use of the module within our college provides an example of its use. Very few of our preservice teachers have experienced PBL as learners, so in our college courses we provide multiple opportunities to learn through PBL, depicted as Phase A of Figure 3. The module described in this article contributes to their next phase (B): understanding of PBL as a teacher. This understanding is key to their Phase C work: designing and implementing PBL as part of their coursework, internships, and student teaching.

Phase C includes student teaching experiences and a critical component of this is the mentor teacher. Thus inservice workshops in summer and during the school year were held with the teachers, and a part of the professional development was completion of the PBL module.

The module fits well into more comprehensive inservice teacher education programs to help participants establish a common understanding of PBL. Two examples of this are proffered. As part of their teacher-led professional development, the teachers in new and diverse STEAM programs at a local school district used one afternoon session for teachers to complete the module. As another example, the primary author of this article is principal investigator of a virtual exchange project in which high school girls in Cairo and Phoenix work together to complete science PBL experiences as the students learn to work with people who are different from themselves. At the onset of the project, participating teachers completed the PBL modules and submitted their certificates. The establishing of a solid foundation allows for the more rapid development of abilities as the teachers work together to design activities.

Summary

Nascent research on PBL suggests its potential for enhancing long-term learning and positive attitudes in K–12 environments. The approach aligns well with new standards and ideals for student-centered education. Successful PBL implementations depend on teachers realizing that their roles and their students' roles will be different from those in in traditional instruction.

Teacher education is a key component for the future of K–12 PBL. An interactive module was conceived as a means to efficiently and effectively lead future and current teachers to understand and implement PBL. The reported stages and substantial hours in development were accomplished by a team with grant funding, and this information can be used to inform planning for similar materials. Future evaluation studies should inform the improvement of this module and development of similar educational materials. The module *Design a Problem-Based Learning Experience* can be part of a comprehensive approach to help preservice and inservice teachers develop the skills, knowledge, and mindsets to effectively use PBL in their classrooms.

References

Batdi, V. (2014). A meta-analysis study comparing problem based learning with traditional instruction. *Electronic Journal of Social Sciences, 13*(51), 346–364.

Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university.* Berkshire, UK: Open University Press.

Boud, D. J., & Feletti, G. (1997). *The challenge of problem-based learning*. New York: St. Martin's Press.

Bridges, E. M. (1992). *Problem-based learning for administrators*. Eugene, OR: ERIC Clearinghouse on Educational Management.

Cook, B. G., & Cook, L. (2004). Bringing science into the classroom by basing craft on research. *Journal of Learning Disabilities, 37*(3), 240–247.

Creswell, J. (2014). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (5th ed.). Boston: Pearson.

Da Silva, A. L., & Dennick, R. (2010). Corpus analysis of problem-based learning transcripts: An exploratory study. *Medical Education, 44*(3), 280–288.

Davidson, N., & Major, C. H. (2014). Boundary crossings: Cooperative learning, collaborative learning, and problem-based learning. *Journal on Excellence in College Teaching, 25*(3&4), 7–55.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Dolmans, D. H., De Grave, W., Wolfhagen, E. H., & van der Vleuten, C. P. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education, 39*, 732–741.

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project-based learning. *Interdisciplinary Journal of Problem-Based Learning, 7*(2). https://doi.org/10.7771/1541-5015.1339

Evans, B. J., Baker, R. B., & Dee, T. S. (2016). Supplementary material for "Persistence patterns in massive open online courses (MOOCs)." *Journal of Higher Education, 87*(2), 206–242. https://doi.org/10.1353/jhe.2016.0006

Finelli, C. J., Daly, S. R., & Richardson, K. M. (2014). Bridging the research-to-practice gap: Designing an institutional change plan using local evidence. *Journal of Engineering Education*, *103*(2), 331–361.

Firdaus, F. M., Wahyudin, & Herman, T. (2017). Improving primary students' mathematical literacy through problem based learning and direct instruction. *Educational Research and Reviews, 12*(4), 212–219.

Greenwood, C. R., & Maheady, L. (2001). Are future teachers aware of the gap between research and practice and what should they know? *Teacher Education and Special Education: The Journal of the Teacher Education Division of the Council for Exceptional Children*, *24*(4), 333–347.

Haury, D. L., & Rillero, P. (1994). *Perspectives of hands-on science teaching and learning* (pp. 142). Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Horak, A. K., & Galluzzo, G. R. (2017). Gifted middle school students' achievement and perceptions of science classroom quality during problem-based learning. *Journal of Advanced Academics, 28*(1), 28–50.

Jensen, K. J. (2015). A meta-analysis of the effects of problem- and project-based learning on academic achievement in grades 6–12 populations. *Education Dissertations, 7*. http://digitalcommons.spu.edu/soe_etd/7

Jerzembek, G., & Murphy, S. (2013). A narrative review of problem-based learning with school-aged children: Implementation and outcomes. *Educational Review, 65*(2), 206–218.

Jones, M. L. (2009). A study of novice special educators' views of evidence-based practices. *Teacher Education and Special Education*, *32*(2), 101–120.

Kennedy, M. (1997). The connection between research and practice. *Educational Researcher, 26*(7), 4–12.

Knowles, M. (1980). *The modern practice of adult education: Andragogy versus pedagogy.* Englewood Cliffs, NJ: Cambridge Adult Education.

Koh, K., & Tan, C. (2016). Promoting reflection in preservice teachers through problem-based learning: An example from Canada. *Reflective Practice, 17*(3), 347–356. https://doi.org/10.1080/14623943.2016.1164683

Lehman, J. D., George, M., Buchanan, P., & Rush, M. (2006). Preparing teachers to use problem-centered, inquiry-based science: Lessons from a four-year professional development project. *Interdisciplinary Journal of Problem-Based Learning, 1*(1). https://doi.org/10.7771/1541-5015.1007

Liao, Y-C., Ottenbreit-Leftwich, A., Karlin, M., Glazewski, K., & Brush, T. (2017). Supporting change in teacher practice: Examining shifts of teachers' professional development preferences and needs for technology integration. *Contemporary Issues in Technology and Teacher Education, 17*(4).

Maxwell, N. L., Mergendoller, J. R., & Bellisimo, Y. (2005). Problem-based learning and high school macroeconomics: A comparative study of instructional methods. *Journal of Economic Education*, *36*(4), 315–331.

McCarthy, J. (2014). Implications of online learning for nurse managers. *Nursing Management, 21*(7), 23–27.

Merritt, J., Lee, M., Rillero, P., & Kinach, B. M. (2017). Problem-based learning in K–8 mathematics and science education: A literature review. *Interdisciplinary Journal of Problem-Based Learning, 11*(2). https://doi.org/10.7771/1541-5015.1674

Opdenakker, M. C., & Van Damme, J. (2006). Teacher characteristics and teaching styles as effectiveness enhancing factors of classroom practice. *Teaching and Teacher Education*, *22*(1), 1–21. https://doi.org/10.1016/j.tate.2005.07.008

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*, 307–332.

Patton, K., Parker, M., & Tannehill, D. (2015). Helping teachers help themselves: Professional development that makes a difference. *NASSP Bulletin, 99*(1), 26–42.

Pepper, C. (2009). Problem based learning in science. *Issues in Educational Research*, *19*(2), 128–141.

Plano Clark, V. L., & Ivankova, N. V. (2016). *Mixed methods research.* Los Angeles, CA: Sage.

Pourshafie, T., & Murray-Harvey, R. (2013). Facilitating problem-based learning in teacher education: Getting the challenge right, *Journal of Education for Teaching, 39*(2), 169–180.

Pugsley, J. (2013, December 6). How to use white papers to sell to businesses. *The Guardian*. https://www.theguardian.com/small-business-network/2013/dec/06/how-to-use-white-papers-sell-to-business

Rico, R., & Ertmer, P. A. (2015). Examining the role of the instructor in problem-centered instruction. *TechTrends, 59*(4), 96–103. https://doi.org.ezproxy1.lib.asu.edu/10.1007/s11528-015-0876-4

Rillero, P. (2015). *Problem-based learning and its components*. Phoenix, AZ: Integrating STEM, Literacy, and Language to Prepare All Teachers to Teach English Language Learners: iTeach ELLs grant, funded by the U.S. Department of Education.

Rillero, P., Koerner, M., Jimenez-Silva, M., Merritt, J., & Farr, W. (2017). Developing teacher competencies for problem-based learning pedagogy and for supporting learning in language-minority students. *Interdisciplinary Journal of Problem-Based Learning*, *11*(2). https://doi.org/10.7771/1541-5015.1675

Rillero, P., Thibault, M., Merritt, J., & Jimenez-Silva, M. (in press). Bears in a boat: Science content and language development through a problem-based learning experience. *Science Activities*. https://doi.org/10.1080/00368121.2017.1406323

Simmons, V., Villa, L., & Borden, R. (2016). Best practice in bridging the theory to practice gap: On-demand modules and accompanying coaching guides. In G. Chamblee & L. Langub (Eds.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2016* (pp. 390–393). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).

Strevy, D. (2014). Focus on teacher education: Project-based learning: Is there a problem-based difficulty? *Childhood Education, 90*(6), 462–465. https://doi.org/10.1080/00094056.2014.983026

Strobel, J., & van Barneveld, A. (2009). When is PBL more effective? A meta-synthesis of meta-analyses comparing PBL to conventional classrooms. *Interdisciplinary Journal of Problem-Based Learning, 3*(1), 44–58. https://doi.org/10.7771/1541-5015.1046

Vanderlinde, R., & van Braak, J. (2010). The gap between educational research and practice: Views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal, 36*, 299–316.

Williams, D., & Coles, L. (2007). Evidence-based practice in teaching: An information perspective. *Journal of Documentation*, *63*(6), 812–835.

Yukhymenko, M. A., Brown, S. W., Lawless, K. A., Brodowinska, K., & Mullin, G. (2014). Thematic analysis of teacher instructional practices and student responses in middle school classrooms with problem-based learning environment. *Global Education Review, 1*(3) 93–110.

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