Planting the Seed: Growing Community-Based PBL Teachers with BLOSSOMS

Invited Paper

Eury Hong
Teachers College, Columbia University

Anthony M. Perry
Massachusetts Institute of Technology

Abstract:

Community-based Project-Based Learning (PBL) is a promising practice to improve secondary STEM education. In these projects, students design and conduct authentic investigations with community stakeholders and technical experts. The work culminates with a public display of authentic artifacts like evidence-based advocacy reports or engineering design prototypes. High-quality PBL in STEM demands rigorous disciplinary learning, develops generalizable skills like critical thinking, and inspires more students to pursue STEM-related pathways after high school. As the evidence base in support of PBL grows, so has the availability of high-quality, PBL instructional materials. However, the availability of materials has not substantially increased the number of students experiencing community-focused PBL. One barrier to implementation is that many teachers lack the confidence to use PBL in their classrooms. This paper describes the design and implementation of a half-day workshop to help teachers implement community-based PBL utilizing MIT's Blended Learning Open Source Science Or Math Studies (BLOSSOMS) project. The workshop is designed for teachers to become familiar with existing instructional materials for PBL and develop an understanding of how these materials can be used in their future classrooms. The workshop utilizes the principles of PBL to develop confidence in novice PBL teachers to adopt this pedagogy in their classrooms. We suggest that pairing teacher workshops with a dynamic, open-source PBL curriculum repository has the potential to exponentially increase the capacity and quantity of STEM teachers who utilize PBL.

Keywords: Project-based learning, STEM Education, Instructional Materials, Student Engagement, Teacher Professional Learning

Introduction

A group of five students is standing outside the main road to the school's entrance with clipboards in hand. The last bell rang two hours ago yet these students remain at school intently watching cars pass through the signalized intersection. A camera is set up to record all traffic to capture car and pedestrian wait times at the traffic light. Tomorrow, they will use these data in math class to update models of the traffic flow and delays. Ultimately, this group is committed to reducing traffic congestion around their school which causes delays and frustration for all drivers in the neighborhood. The students think different traffic light timing, with smart sensors, might make a measurable difference. Next week, the group meets with a city traffic engineer to receive feedback on their proposals to achieve these goals. Their modeling and recommendations also take into consideration the impact on local air quality and CO_2 emissions caused by idling cars. With support from the technology teacher and a local environmental engineer, two students on the project have obtained air quality sensors that will be placed at the intersection to collect baseline data. The students are excited about their scheduled presentation at the next town meeting where they will present their recommendations.

This scenario describes a range of student activities supported by **community-based project-based learning** (PBL). In PBL, students are motivated to learn course content and skills in multiple STEM disciplines because it is necessary to effect change. This projects also blurred the divide between a school and its community. Students collected real data, visited industry professionals to advance their understanding of this complex issue, and were treated as capable young adults taken seriously by community members and STEM professionals.

Prior studies suggest that PBL has multiple benefits. Students become comfortable working with uncertainty and develop critical thinking skills (Dabbagh, 2019) without sacrificing core disciplinary learning goals (Schneider et al., 2022). Including the community members in PBL is associated with helping students find relevance in their coursework (Bowen & Peterson, 2018; Nicholas & Scribner, 2021) and developing student interest in STEM careers (LaForce et al., 2017). These experiences can be transformative. Students adopt the identity of agents of change in their community by applying STEM knowledge and skills (Montoya et al., 2018, 2021).

Community-based PBL, despite this evidence, is rare in most American high schools. Most students report math and science to be their least engaging courses during the school day where the most common learning experiences are passive like lecturing (Shernoff et al., 2003). Despite nearly 100 years of efforts to improve STEM teaching, the high school student experience has, on the whole, changed very little (Cuban, 2013). Creating a more engaging student learning experience will require structural changes to the educational system (Perry, 2022).

One reason implementing PBL can be difficult is that it requires teachers to take on new roles in the classroom. Becoming a facilitator of open-ended learning and allowing public displays of student work can be nerve-wracking. This manuscript describes two innovations designed to support STEM teachers through the early phases of adopting PBL. First, the MIT Blended Learning Open Source Science or Math Studies (MIT BLOSSOMS; blossoms.mit.edu) initiative created a set of free student and teacher resources that address many common misconceptions teachers, students, and parents hold regarding PBL. Second, we show how these materials can be paired with a half-day workshop for teachers allowing STEM teachers to experience elements of PBL. In doing so, they become PBL-ready—confident to adopt this approach in their classroom. We envision a combined lesson-sharing and teacher learning system that can exponentially grow the number of PBL-ready teachers.

MIT BLOSSOMS

BLOSSOMS was founded in 2008 as a repository of free, high-quality, interactive STEM videos for use in classrooms across the world. The videos empower teachers to focus on the interactive and engaging elements of instruction while the videos introduce and explain concepts by subject matter experts in authentic contexts (Larson & Murray, 2008). In 2018, BLOSSOMS was extended to include resources for PBL. The site hosts six sample projects which use existing BLOSSOMS videos to support multi-day, community-focused PBL as shown in figure 1. The project resources contain enough detail for a teacher to implement the unit including a video teacher guide, project calendar, assessment rubrics, and connections to common learning standards. The site also contains resources that provide practical answers and strategies to address common misconceptions teachers (Fallik et al., 2008), students (Grant, 2011), and parents

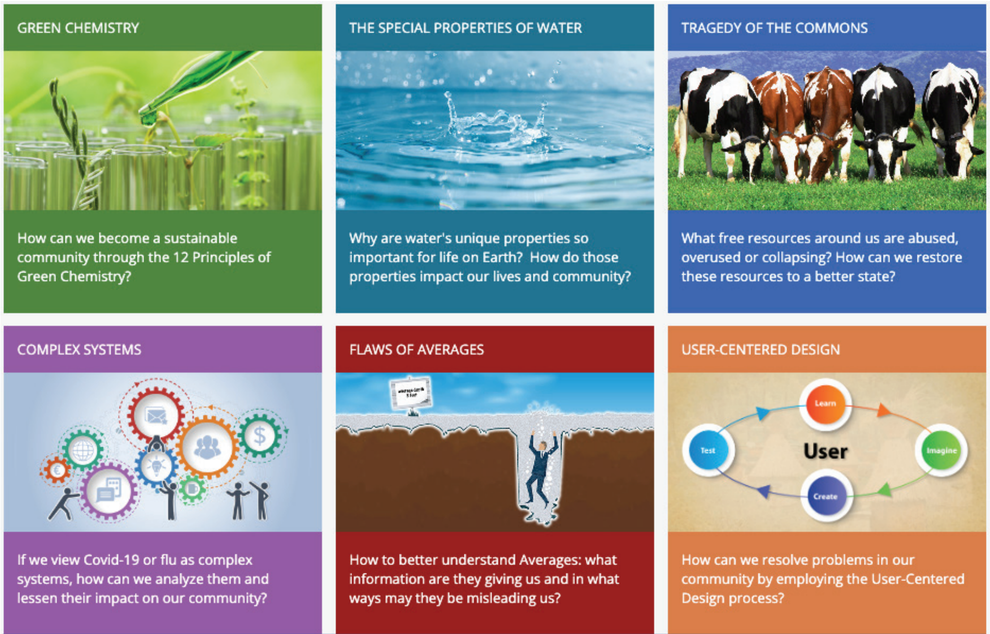

Fig. 1. Six PBL units available on MIT BLOSSOMS website

(Aldabbus, 2018) raise about PBL. A full description of the BLOSSOMS PBL design is described in Cammarata and Larson (2018).

Effective Open Source Resources for Novice PBL Teachers

The BLOSSOMS PBL materials were designed to provide teachers with all the instructional materials needed to implement a project in their classroom. We borrow the analogy of plant growth to describe this approach. The instructional materials are the "seed" of PBL. Teachers use supporting documents and strategies hosted on the project's site to create a fertile environment allowing effective and engaging instruction to "blossom" in their classrooms. As an example, consider the *Flaws of Averages* project.

Students first engage with a BLOSSOMS video covering the mathematical concept of average and how, at times, it can be an unhelpful measure for decision-making. Following the video, students conduct mini-investigations and explore this concept within the classroom population. This exploration serves as a launching point for the larger project.

The central project driving the unit is related to community safety. Students are placed in groups and choose a context meaningful to them. BLOSSOMS provides examples of contexts including the distribution of fire hydrants, intersection safety, smart traffic lights, sidewalk safety, and playground safety. If students focus on intersection safety, for example, they will identify the safety of the location of objects near intersections that obscure driver visibility like trees or bushes. STEM knowledge from multiple disciplines is needed (mean, median, geometry, speed, and acceleration) to investigate this locally relevant issue and create models which quantify the safety of an intersection. Throughout the course of this project, students may self-teach new math skills with support from the classroom teacher as they calculate the appropriate location of stop signs. Physics concepts like speed and acceleration are useful in modeling the impact of an overhanging tree on safety. Students engage with the local laws and their safety models to create ameliorative suggestions for improving safety with the community stakeholders. For the final event, students write a report summarizing their findings and present their work in a public forum.

Krajcik (2015) describes the essential features of project-based learning and high-quality STEM learning. Table 1 demonstrates a strong alignment between these elements and the *Flaws of Averages* project design. The open-source materials and guidance on BLOSSOMS enable teachers to implement rigorous and engaging community-based PBL.

Planting the Seeds for PBL with a Teacher Workshop

Despite the presence of high-quality, free, community-focused PBL instructional materials, these practices are not commonplace in American high schools. Teachers may not be familiar with existing resources or not confident in implementing PBL in their local context. Returning to the plant analogy, it is critical to recognize that some seeds disburse and flourish through natural, ecological forces. Human intervention is needed, however, to ensure the seeds are planted and take hold in desired environments. PBL could become a widespread practice with an intervention that "plants the seeds" across the country.

Prior research demonstrates that pre-service (Tsybulsky & Muchnik-Rozanov, 2021) and in-service (Fallik et al., 2008) teachers learn and adopt PBL strategies best when they have first-hand experience with the pedagogy. Interest in PBL has grown in recent years and new professional learning opportunities exist to support teachers from university-based projects, internal district

Element	Description	Presence in BLOSSOMS
Solving relevant questions	Projects are driven by questions relevant to student lives	The unit provides five example community safety projects which can be adapted to rural, suburban, and urban communities
Planning and carrying out investigations	Students develop procedures and use data to answer the unit's driving question	Students devise quantitative measures of "safety" relevant to their project, collect data, and create mathematical models of community safety
Collaborating with students, teachers, and members of society	The driving questions are so large that students must collaborate with each other, leverage differences in interests/skills, and collaborate with subject matter experts in pursuit of a satisfying resolution to the question	Students are placed in teams, work with teachers to develop relevant disciplinary knowledge and skills for data analysis and modeling, and reach out to local experts who have expertise to solicit feedback on proposed solutions to safety issues in the community
Producing artifacts	Projects culminate with the production and presentation of authentic artifacts	Students crate a written report and public presentation to demonstrate their findings and suggest ways to improve community safety
Using technology, when appropriate	Use technology in data collection, analysis, and presentations	Students may utilize technologies for data collection and presentation. For example, a team interested in sidewalk safety may use an accelerometer and GPS to collect data of bumps felt by people in wheelchairs, use computational tools to quantify sidewalk "bumpiness", and use Google Maps to visualize the distribution of bumps and their intensity.

Table 1. Elements of PBL in a sample BLOSSOMS unit

support, and non-profit organizations like PBLWorks. However, these opportunities require multi-day or even multi-year commitments (e.g., Zhang et al., 2019). This presents a barrier to access; especially for teachers who may not be confident they can successfully implement PBL. A short and easily accessible workshop is appropriate to engage a wide range of STEM teachers with PBL for the first time.

Below, we describe the components of a workshop designed with this principle in mind. This workshop is meant to be the first exposure to PBL and develop a teacher's belief that they can successfully implement PBL in their classroom with their students. The workshop incorporates Krajcik's elements of PBL (2015) so teachers can experience PBL from the point-of-view of a student and teacher which is known to develop competence and confidence (Fallik et al., 2008).

Teacher Recruitment

Teachers were recruited to participate by reaching out to local STEM teacher associations and STEM department chairs at high schools in the Metro Boston region. The free workshop was held on a Saturday from 9:00 a.m. – 2:00 p.m. including a working lunch provided by the workshop hosts. Sixteen teachers from multiple STEM disciplines registered for this event. Six of the registrations came from local districts that have encouraged teachers to adopt PBL but the teachers indicated there were minimal internal supports to facilitate this instructional change.

Workshop Design

The half-day workshop was designed around three learning goals. Participants should be able to…

1) Adapt and develop community-focused PBL in their classroom
2) Apply students' prior knowledge about PBL as a pedagogy to design and implement instruction
3) Connect with local teachers to share challenges and excitement for PBL

The activities were designed to be interactive and model PBL strategies to develop teacher comfort with difficult strategies such as supporting teamwork and project management.

After a round of introductions, teachers were launched into a sample PBL using the *Flaws of Averages* BLOSSOMS project as an exemplar. The workshop facilitator played a video about a person who uses a wheelchair's perspective navigating city streets to orient the group to a real, addressable need. Next, the group used Google Street View to investigate sidewalk quality around one local school. This oriented learning around a question relevant to local participants. They generated ideas about the kinds of data they might collect to investigate the quality of the sidewalk—planning their own investigations. After a break, the workshop switched back into teacher mode. Participants voiced concerns about implementing PBL and they explored the resources available on the BLOSSOMS website which address those concerns including facilitating group projects, project management tools, and suggestions to communicate the importance of PBL to students and parents. Before lunch, participants were treated with a guest speaker who shared three exemplary cases of community-based PBL so the teachers had concrete examples of engaging and rigorous PBL and how it engages students. The workshop concluded with a final project. Each group was tasked with identifying community members and remixing the sidewalk safety unit to fit into a school and course context. Adapting existing instructional materials is a core skill teachers can use to create PBL units (Bybee, 2020) without needing the time and expertise to develop units from scratch. The project also provides an opportunity for teachers to address PBL implementation concerns in a supportive environment with peers. The day culminated with each group sharing out sketches of the PBL units they can implement in the future.

Post-Workshop Evaluation

Workshop participants completed a workshop evaluation survey before leaving. The opened ended responses indicate this design met the intended goal of preparing PBL-ready teachers who are confident in their ability to adopt these practices in their classroom. One respondent noted: "I feel good about how I could incorporate the community into my class. Hearing about other experiences with PBL…helps." These teachers are now PBL-ready. Each has enough familiarity with the BLOSSOMS instructional materials and the confidence to implement a community-based project in their classroom for the first time.

Continuing the PBL Learning Journey

As described in this article, short workshops and high-quality, open-source instructional materials can catalyze a teacher's journey into community-based PBL. The "seed planting" metaphor resonates with Guskey's well-tested model of continuous teacher development (1986)particularly through staff development programs. The model suggests a temporal sequence of events that is hypothesized to typify the process front staff development to enduring change in teachers' perceptions and attitudes. Research evidence supporting the model is summarized and the conditions under which change might be facilitated are described. Several principles for enhancing the change process to improve staff development efforts are also outlined", which describes how a teacher's attitudes toward new instructional techniques will change when they see improved student outcomes from innovative teaching practices. The workshop placed in-service teachers in a supportive environment where they could be exposed to and experience the practices of PBL first-hand. In the post-workshop survey, the educators reported a better understanding of PBL and are more confident that they can implement PBL in the future. Their journey into PBL now begins.

Accelerating Community-Based PBL Adoption with Technology

The approach to expanding the number of PBL-ready teachers is promising, not only because of its impact on attendees but also because of its potential to drive systemic change. As others have suggested, pairing in-person professional learning with dynamic curriculum repositories can be an effective lever to transform the teaching practice (Hird et al., 2014). A future version of the BLOSSOMS instructional material repository could

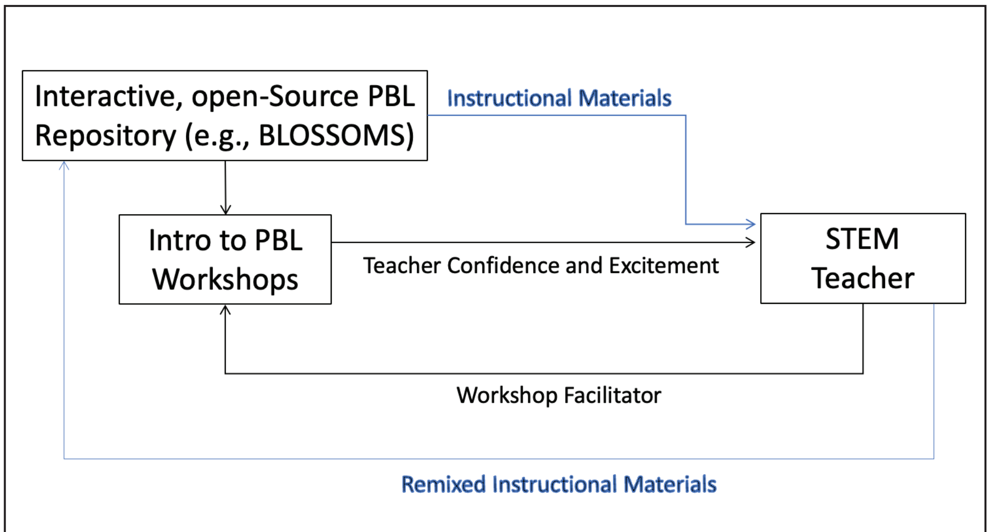

Fig. 2. The idealized dynamic workshop-PBL repository system

allow teachers to upload remixes of the instructional materials created for use in their classrooms. The teacher workshop described in this article, just like the BLOSSOMS PBL materials, can also be replicated by other experienced PBL teachers.

Figure 2 is an idealized visualization of how pairing introductory workshops and a dynamic curriculum repository can spur exponential growth in the number of teachers confident to implement community-based PBL in their classrooms. Some participants in each workshop will develop community-based PBL expertise through repeated practice in their own classrooms. These leaders can propagate this approach by facilitating workshops in their own schools and communities. Teacher-led PD is effective professional learning with the added benefit of retaining experienced and effective teachers (Podhorsky & Fisher, 2007). Allowing experienced teachers to share remixed instructional materials will make the diversity of implementation in local contexts visible. These materials will be useful to novice teachers who need concrete examples to try community-based PBL for the first time.

This article describes how pairing open-source instructional materials like BLOSSOMS with an introductory teacher workshop addresses a key barrier to the widespread implementation of community-focused PBL in high school STEM classrooms. A dynamic instructional material repository, paired with distributed "planting the seeds of PBL" workshops can exponentially grow the number of teachers using this engaging and effective strategy in their classroom. Such a platform could be evaluated with longitudinal studies to trace workshop participants over time to observe the implementation of community-based PBL in classrooms and leadership activities like sharing new materials or training more teachers.

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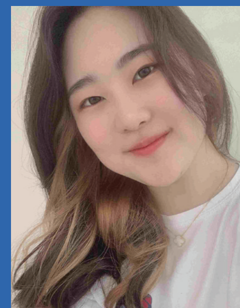
Eury Hong is an M.A. student in Instructional Technology and Media at Teachers College, Columbia University. She earned her B.A. in Media Arts and Sciences from Wellesley College and cross-registered at the Massachusetts Institute of Technology (MIT). She now works as a research assistant in the TLTLab and collaborates with the Korea Advanced Institute of Science & Technology (KAIST). Her research focuses on designing and developing constructionist computational learning to promote inclusive and equitable education including cultural-making practices in STEAM education, AI thinking to *AI Action*, and AI-powered learning in both formal and informal settings. eh3011@tc.columbia.edu



Anthony M. Perry is an Assistant Professor of STEM education at the University of North Dakota, where his research focuses on equitable student engagement with emerging technology college and career pathways. He uses multiple methodological and theoretical approaches to investigate, (re)design, and improve education systems. anthony.m.perry@und.edu