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## Preface

### A Little about Our PBL Work

This book is the result of the editors' work of many years training teachers to help them embrace and learn to implement high-quality project-based learning (PBL). It has been very rewarding to collaborate with teachers to learn together about the essential principles of PBL and walk together the challenging path that goes from never having used PBL in the classroom to successfully implementing PBL units. It has been even more rewarding to hear the stories of the teachers that we have worked with about their sense of self as a mathematics teacher and the changes they have seen in their students and how their students have become more engaged in the classroom. We also have taught our courses using PBL and found every time the experience transforms the culture of our classrooms.

### Motivation for This Book

We wanted to share our positive experiences with PBL so that other teachers and educators could also benefit from this work. Our first book, *Rigor, Relevance, and Relationships: Making Mathematics Come Alive with Project-Based Learning* (2018), consists of secondary mathematics PBL units. At various speaking engagements and networking opportunities, many elementary teachers were requesting a PBL book that addresses the mathematics at the elementary level. Seeing this unmet need, we proceeded in writing this book for elementary school teachers. We thank NCTM for giving us this opportunity, and we thank various teachers who encouraged us to write this book, as well as those who contributed.

### The Purpose of This Book and How to Use It

This book is written for K–6 teachers who may be new to PBL or who have tried it before but would like to improve their practice. This book can also be used by educators who are training preservice or in-service teachers on how to get started on implementing PBL in elementary schools. This book is designed to provide easy-to-read, practical, step-by-step advice about planning and implementing a PBL unit while focusing on three cornerstones of PBL: (1) rigor, (2) relevance, and (3) relationships. We also include some tools and tips to help you do it well.

Readers can adapt the sample PBL units and use them in their own instructional setting. We also encourage readers to design and implement new PBL units for their own use and to share with the broader community of mathematics educators. Readers are also encouraged to use the templates included in chapter 1 (e.g., Project Planning Form, Scaffolding NTKs, Project Calendar) to aid in the design process.

### Organization of This Book

This book is divided into four sections. In the first section, we introduce a teaching methodology called project-based learning (PBL). We describe the nuts and bolts of designing an effective PBL unit (chapter 1); leveraging rigor, relevance, and relationships; and the NCTM Mathematics

Teaching Practices in PBL environments (chapter 2). A literature review on the effectiveness of PBL and how it informs classroom practice is also presented (chapter 3).

The second and third sections of this book showcase PBL units that have been designed and implemented by elementary teachers in their classrooms. Each unit addresses the essential elements of PBL, discusses the connections to the Common Core State Standards for Mathematics and NCTM Mathematics Teaching Practices, and provides readers with access to supplemental materials such as the following:

- A project planning form and project calendar containing details about the project
- Rubrics used throughout the project
- Written and digital examples of critical points in the PBL process, such as the launch of the project, establishment of effective small-group norms, peer critiques, and project presentations
- Examples of student work and student learning
- Other resources that help make PBL effective in mathematics classrooms

In particular, the second section includes *detailed* PBL units with several highlighted lesson plans. The third section contains *brief* PBL units. Both detailed and brief PBL units may have supplementary digital resources that can be found at [www.nctm.org/more4u](http://www.nctm.org/more4u). Also, all the PBL units include tips on how to sustain the rigor, engage learners in relevant learning, and encourage students to build relationships with their peers and members in the community.

We comment on some of the strengths of each PBL unit so readers can take note as they read each chapter.

- “Empowering Our Youngest Learners: Designing a Sensory ‘Recess Path’ Using Early Elementary Math” (chapter 4) engages learners in an interdisciplinary unit including mathematics, science, and English language arts content while foregrounding the learning of counting, cardinality, data, and measurement. The unit is described in terms of milestones that carry the inquiry of the project forward.
- “Keeping Indianapolis Warm: Learning about Empathy and Homelessness” (chapter 5) is a service learning project. It equips learners to make fleece blankets, have a positive impact on the homeless community, and develop a foundation for empathy while learning about geometric measurement and area and perimeter.
- “Yes, We Can: Help the Hungry in Our Community through CANstruction” (chapter 6) is a service learning project and teaches learners how to build structures out of canned goods while learning about nutrition and bringing awareness to hunger. Students learn how to solve problems involving measurement and conversion of measurements and use place value and properties of operations to perform multidigit arithmetic. The unit is highlighted in terms of Universal Design for Learning (UDL) principles.
- “Creating Digital Content Using Stop-Motion Animation: Delving into Expressions and Equations” (chapter 7) engages learners in producing stop-motion animation videos as they learn about algebraic expressions and equations. This chapter is a great example of how to scaffold non-PBL learners’ experiences by implementing some PBL practices in a mathematics classroom.

- “Characters Like Us: Using PBL to Advocate for Representation in Media” (chapter 8) combines social justice, mathematics, and literacy. Using learners’ lived experiences, they advocate for the diversity of cartoon characters that resemble themselves on various television networks. Students learn how to represent and solve problems involving addition and subtraction and how to represent and interpret data.
- “Grid City: Designing Math Towns and Encouraging Bright Minds” (chapter 9) situates the learners as civil engineers with required building codes. Students learn how to listen to one another and cooperatively work in teams. This chapter is an excellent example of a unit that could be replicated each year; it involves numerous mathematics concepts such as developing an understanding of fractions as numbers, solving problems involving multiplication and division, reasoning with shapes and their attributes, and understanding concepts of area.
- “Designing Chocolate Boxes: Diving into Factors and Geometry” (chapter 10) builds on learners’ understanding of multiplication factors using an array model. Learners investigate ways to design chocolate boxes to fit different assortments of chocolates. This chapter also could be replicated each year.
- “Pond Mapping and Saving Our Fish: Bringing Authenticity into the Classroom” (chapter 11) is a unit that was designed on the basis of an urgent real-life problem a school was having. It empowered learners to help the administration solve the problem. Learners graphed points on a coordinate plane to map out the school’s pond, and they created and used tools to measure the depth and volume of the school’s pond to save the fish from freezing during the winter.
- “Poverty, Health, and Disease: Ratios, Rates, and Proportions that Impact Our Lives” (chapter 12) positions learners to be globally aware of the world around them and exposes learners to research skills and practices. Learners engage in ratio concepts and use ratio reasoning, develop an understanding of statistical variability, and summarize and describe distributions. The content of this unit could be used to capitalize on various maladies, including the recent COVID-19 pandemic.

The final section of the book includes lessons learned, tips, and resources for elementary teachers. Chapter 13 is written by a math coach who has taught in PBL settings. Chapter 14 is written by a mathematics educator who has researched and taught in PBL settings.

## Editors’ Biographies

**Dr. Jean Lee** is an associate professor in the School of Education at the University of Indianapolis. She currently teaches undergraduate and graduate mathematics education and curriculum courses. Dr. Lee is a PBL-certified and a licensed secondary mathematics teacher. She also continues to work in urban and rural classrooms to support K–12 preservice teachers as well as novice and veteran mathematics teachers. Dr. Lee has been involved in leading various professional development projects, working with teachers at the state and international levels. Her research interests include PBL and the preparation of teachers for high-need, urban school settings.

**Dr. Enrique Galindo** is an associate professor of mathematics education at Indiana University Bloomington. He is interested in research on teacher education and on learning in technology-supported environments. He teaches courses on mathematics and pedagogy, secondary mathematics methods courses, and graduate courses for teacher educators. He has directed many large-scale funded projects and has many years of experience with professional development. He has conducted professional development projects to help teachers in K–12 improve teaching and learning in STEM education, incorporate PBL, and develop their technological and pedagogical knowledge to improve their teaching.