Years 3–6

10 Projects for the PBL Classroom: Maths

REVISED EDITION
FOR THE AUSTRALIAN CURRICULUM

Todd Stanley

Hawker Brownlow EDUCATION

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INTRODUCTION

Why Project-Based Learning?

Twenty-first century skills, or survival skills, as termed by Tony Wagner in his book *The Global Achievement Gap* (2014), involve students being able to do more than memorise facts and instead apply skills and, more importantly, problem solve (Stoof, Martens, Van Merriënboer & Bastiaens, 2002). In short, teachers are tasked with the difficult job of trying to create thinkers. This results from businesses complaining that the best and brightest students that the educational system is sending their way are very intelligent but woefully inept at figuring out problems, arguing students know a lot of "facts" but are not "competent" (Bastiaens & Martens, 2000). Any teacher able to help students become these thinkers would be providing them with an advantage when they enter the real world.

The educational system has to do a better job of preparing students to solve real-world problems. How do we do that in the current system of standards and testing? With so much at stake on these achievement tests, the bigger question is: How often in life are we asked to take a pencil-and-paper test? Not very often unless you count online personality quizzes. In real life we are usually dealing with projects, either at work, home or other settings. If we truly want to get students ready for the real world, we should be teaching them how to handle the real-world dilemma of a project.

As mentioned in *Project-Based Learning for Gifted Students: A Handbook for the 21st-Century Classroom* (Stanley, 2012), according to the Buck

Institute for Education, research studies have demonstrated project-based learning can:

- increase academic achievement on standardised assessment tests;
- teach maths, economics, humanities, science and health-related subjects more effectively than traditional teaching methods
- increase long-term retention of knowledge, skill development and student and teacher satisfaction
- prepare students to integrate and explain concepts better than traditional instructional methods
- prove especially helpful for low-achieving students;
- present a workable model for larger school reform
- help students to master 21st-century skills such as communication, independent and critical thinking and research. (p. 4)

This is why project-based learning is such a good fit for creating such thinkers. It has been discovered that students:

- prefer to structure their own tasks they are working on and establish deadlines as opposed to having the teacher assign them (Dunn & Dunn, 1984; Renzulli & Smith, 1982; Stewart, 1980)
- learn more and retain content more accurately when allowed to work on projects in which they set the pace (Whitener, 1989)
- show an increased benefit in learning when they teach each other through projects (Kingsley, 1986; Johnsen-Harrris, 1983)
- show improvement in cooperative learning skills when working in groups because they must work together to solve problems (Peterson, 1997)
- show increased engagement after participating in PBL than students who did not (Grant & Branch, 2005; Horton et al., 2006; Johnston, 2004; Jones & Kalinowski, 2007; Ljung & Blackwell, 1996; McMiller, Lee, Saroop, Green & Johnson, 2006; Toolin, 2004).

Based on this research, a better question to ask is not why use project-based learning, but rather why not use project-based learning?

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What Are the Advantages of Using PBL in a Mathematics Classroom?

Project-based learning is an excellent vehicle to teach 21st-century skills. In *21st-Century Skills: Learning for Life in Our Times* (2009), Bernie Trilling and Charles Fadel mentioned, among valuable 21st-century skills, eight specific skills that PBL can effectively teach:

1. public speaking
2. problem solving
3. collaboration
4. critical thinking
5. information literacy
6. creativity
7. adaptability
8. self-direction. (p. viii)

Maths lends itself to problem solving, the very nature of maths. Combining this with project-based learning, problem solving becomes relevant. For example, if you teach students that $2 + 2 = 4$, it is an abstract form, merely a group of numbers that combine to make a different number. But the problem can be more concrete: *Bobby has two pieces of gum and Greg has two pieces of gum. How much gum do they have if they combine them?* Now the 4 becomes more than a number; it becomes potentially more gum, something you can literally sink your teeth into. If you apply mathematical problem solving to a real-world problem, then students will benefit because they see how it can be used. In an episode of *The Simpsons* titled "The Dead Putting Society" (Martin, 1990), Lisa tries to help Bart become better at miniature golf, so that he can win a bet for his father:

> **Lisa:** The basis of this game is simple geometry. Just hit the ball here.
> *(Bart does so and gets a hole in one.)*
> **Bart:** I can't believe it. You've actually found a practical use for geometry.

Getting students to think about mathematics in the real world and solving real-world problems will enable students to better understand

maths. Just like Bart, they may find a practical use for it. This ties in to many of the content descriptions listed in the National Curriculum for Years 3–5, such as:

1. Patterns and algebra: Explore and describe number patterns resulting from performing multiplication
2. Solve word problems by using number sentences involving multiplication or division where there is no remainder
3. Use estimation and rounding to check the reasonableness of answers to calculations
4. Calculate perimeter and area of rectangles using familiar metric units
5. Solve problems involving purchases and the calculation of change to the nearest five cents with and without digital technologies
6. Find unknown quantities in number sentences involving addition and subtraction and identify equivalent number sentences involving addition and subtraction
7. Convert between units of time
8. Use simple scales, legends and directions to interpret information contained in basic maps

Critical thinking is also key. This is problem solving at a higher level of thinking. Most educators are familiar with Bloom's taxonomy. The lower level thinking skills are represented by:

1. remembering
2. comprehending
3. applying.

There is a lot of *applying* in maths, applying mathematical concepts and formulas and solving a problem using them. But how much higher level thinking are we doing in maths? Many students find maths difficult to understand. However, this does not mean it is at a higher level of thinking. You can give a student the following problem: *2.769 times 10 to the negative third power equals what?* This problem may cause one to pause in solving it (the answer is .002769, by the way), but students are still using the principle of application, a lower level thinking skill. Thinking at a higher level means accessing the following thought processes:

- analysing
- evaluating
- creating.

The student's goal in an oral presentation is to verbally teach classmates or the audience what they have learnt after researching a particular topic or skill. A successful oral presentation needs to be set up just like an essay would, with a topic sentence, supporting details and several drafts before the final presentation. This structure is something that should be taught to students. This can be done with modelling, looking at exemplary examples of great oral presentations or practising presentations with no consequences.

Having Your Maths and Eating It Too

Baking a cake or cookies involves maths, especially fractions. How much of each ingredient to put in, what measurement for those ingredients, how long to bake, how much it will make and so on, are all factors.

In this project, students will work in groups to bake a product, using various kinds of maths. Each group will bring its product and recipe to share with the class. Their recipes must involve maths problems that others must solve in order to determine the amount of ingredients to use. They will teach the class using the problems they create, demonstrating equivalent fractions, adding and subtracting fractions with different denominators and multiplying and dividing fractions.

Materials

- Project Outline: Having Your Maths and Eating It Too (student copies)
- Suggested Timeline
- Lesson: Using a Recipe
- Lesson: The Basics of Fractions
- Lesson: Adding and Subtracting Fractions With Different Denominators
- Lesson: Multiplying Fractions by Whole Numbers
- Lesson: What Makes a Good Presentation?
- Handout 1.1: Chocolate Chip Cookie Recipe (student copies)
- Handout 1.2: Fractions (student copies)
- Handout 1.3: Different Denominators (student copies)

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Design Your Own Waterpark

Who doesn't like the waterpark? With slides, tunnels, whirlpools and whatever else, there is something for everyone.

In this project, students will work in groups to create their own waterpark that provides entertainment for as many different people as possible. They must develop rides and attractions, as well as determine the depth of each pool and calculate the volume and how much water will be needed. They should create a floor plan for this waterpark or even a model of what it will look like. Each group will present its waterpark to "investors", an authentic audience of your choosing, convincing them to build its waterpark.

Materials

- Project Outline: Design Your Own Waterpark (student copies)
- Suggested Timeline
- Lesson: What Is Volume?
- Lesson: How Much Water is in the Bathtub?
- Lesson: What Makes a Good Waterpark?
- Lesson: Giving a Professional Presentation
- Handout 2.1: Volume (student copies)
- Handout 2.2: Tips for Giving a Professional Presentation (student copies)
- Product Rubric (student copies)

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