

Project-Based Learning

Material of Course on Joyful Learning in Mathematics
for Primary School Mathematics Teacher
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Introduction

A number of teaching and learning approaches or strategies have been introduced and developed periodically to upgrade the quality of teaching and learning. Traditional teaching and learning approaches—those that employ narrow tasks to emphasize rote memorization or the application of simple procedures—won't develop learners who are critical thinkers or effective writers and speakers. Rather, students need to take part in complex and meaningful projects that require sustained engagement and collaboration.

Student-centered activities have become the trend in classrooms. One of teaching and learning approach that encourages student's activity is Project-Based Learning. Project-Based Learning is an approach that has transformed the face of learning by engaging students into productive and real-life projects. Project-Based Learning is a good vehicle for helping students make progress on a number of mathematics educational goals not directly covered in the "traditional" math curriculum.

This document provides an introduction to uses of Project-Based Learning in mathematics teaching and learning. It includes arguments supporting use of Project-Based Learning and it includes a number of examples that can be adapted for use in a wide range of math courses at primary education.

What is Project-Based Learning?

Project-Based Learning is a systematic teaching method that engages students in learning essential knowledge and life-enhancing skills through an extended, student-influenced inquiry process structured around complex, authentic questions and carefully designed products and tasks. (Mergendoller & Lenz, 2006). Project-Based Learning built upon authentic learning activities that engage student interest and motivation. These activities are designed to answer a question or solve a problem and generally reflect the types of learning and work people do in the everyday world outside the classroom. Generally, Project-Based Learning is done by groups of students working together toward a common goal. Performance is assessed on an individual basis, and takes into account the quality of the product produced, the depth of content

understanding demonstrated, and the contributions made to the ongoing process of project realization.

Project-Based Learning allows students to reflect upon their own ideas and opinions, exercise voice and choice, and make decisions that affect project outcomes and the learning process in general. Project-Based Learning focuses on engaging students in investigation. Within this framework, students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts or products (Blumenfeld et al, 1991).

Why is Project-Based Learning Important?

The old-school model of passively learning facts and reciting them out of context is no longer sufficient to prepare students to survive in today's world. Solving highly complex problems requires that students have both fundamental skills (reading, writing, and math) and digital-age skills (teamwork, problem solving, research gathering, time management, information synthesizing, utilizing high tech tools). With this combination of skills, students become directors and managers of their learning process, guided and mentored by a skilled teacher. (Edutopia, 2010)

By bringing real-life context to the curriculum through a Project-Based Learning approach, students are encouraged to become independent workers, critical thinkers, and lifelong learners. Project-Based Learning is not just a way of learning; it's a way of working together. If students learn to take responsibility for their own learning, they will form the basis for the way they will work with others in their adult lives.

Recognizing that children have different learning styles, concrete and hands-on experiences come together during Project-Based Learning. Field trips, experiments, model building, posters, and creation of multimedia presentations are all viable activities within Project-Based Learning, and present multiple ways for students to demonstrate their knowledge -- there is no one right answer.

According to Muschla & Muschla (2006), when students work on authentic problems in the Project-Based Learning, they see how the math skills they are learning may be applied to the real world. Math projects open the door to bringing other subjects and disciplines into the mathematics class and students quickly recognize that math is interwoven through many parts of their lives. Mathematics projects also give students

the opportunity to work together cooperatively, overwhelming for one person to manage. In the project-based learning activities, students of all abilities have the chance to contribute to the solution. Everyone has a part to play; everyone has a role to fill; everyone can be a contributor to and a sharer in success.

How does Project-Based Learning Relate to Problem-Based Learning?

While Project-Based Learning and Problem-Based Learning share much in common, they are two distinct approaches to learning. In Project-Based Learning, students have a great deal of control of the project they will work on and what they will do in the project. The project may or may not address a specific problem. In Problem-Based Learning, a specific problem is specified by the course instructor. Students work individually or in teams over a period of time to develop solutions to this problem.

The difference between project-based learning and problem-based learning is as follows.

Table 1. The Difference between Project-Based Learning and Problem-Based Learning

Project-Based Learning	Problem-Based Learning
Activity-based	Inquiry-based
Supplement the curriculum	Part of the curriculum
Minimal assessment	Focused assessments
Broad assessments	Specified outcomes
Loosely managed	Tightly managed
Unstructured	Well structured

How to Create the Math Projects?

Material for math projects is all around us. We should ensure that the projects are stimulating and exciting to the students (Muschla & Muschla, 2006).

- Base the projects on real life situations that are meaningful to your students
- Design projects that capture the interest of the students
- Make sure that the students possess the mathematical skills to solve the problems they will encounter in the products
- Develop projects that require analysis, critical thinking, and decision making
- Create projects that require students to formulate a plan to find solution

For example, when we're designing elementary math projects, begin by thinking about the concept that we want the students or child to utilize and how that concept can be practiced with a project. For example, geometry can be practiced by making pictures with cutouts of polygons. Similarly, measurement skills can be practiced by measuring items around the classroom.

Next, think about how long we want the project to last. We could design a long term graphing project where students create a weather bar graph. Each day, students can add to the bar graph depending on the day's weather. However, if you want a quicker graphing project, you can conduct a survey of how students get to school (bus, walking, car, bike) and create a bar graph with this information.

Although it takes time and effort to design a math project, we will find that the students are excited and motivated to complete them, which will make the math lessons more effective. At home, projects reinforce what the child is learning in school and can help the child understand that math exists outside of the classroom.

The following are examples of mathematics in the classroom project.

1. For a geometry project, have the students create a drawing using geometry concepts like triangles, rectangles, parallel lines, perpendicular lines and right angles.
2. To practice measuring skills, have a scavenger hunt in the classroom. Break the students into groups and ask them to find something in the room that is five feet, four inches, three and a half centimeters, etc.
3. If they want a long-term project, have the students plan a trip somewhere. They will have to calculate how far the destination is from the school. In addition, they will calculate what they will need to buy from the store in preparation. As a result, students practice measuring as well as multi-digit addition.
4. Students can research the history of math for a project. In this type of project, they might research famous mathematicians, contribution to the field of mathematics or the discovery of new mathematical theories. Then they will put together their projects in a way that demonstrates what they have learned and share their information with the class. They might create a slide show, a display board or a scrapbook of historical and mathematical information for a project like this.

At the end of this article presented examples of math projects given by Muschla and Muschla (2006), .ie Puzzling Project and Cake Project.

How to Implement Project-Based Learning?

The steps in implementing Project-Based Learning are as follows.

- To implement Project-Based Learning, first set the classroom for students with real-life samples of the projects they will be doing.
- Allow students to get involved into the role of project designers and produce a display or competition.
- Using computers or other technology, allow students to gather information needed for their project of design and let them discuss in the class.
- Involve students in creating the rubric for the project. They must know how they will be evaluated or what is expected out of them.
- Let students collect all the materials they need to complete their project.
- Once, all set give students time to finish their project with their final best touch within the duration you provided.
- Let students present their projects.
- After everyone is done presenting, create a discussion and give feedback.
- Finally, evaluate the projects based on the criteria you and your students created at the beginning of the project.

How to Manage Problem-Based Learning?

According to Muschla & Muschla (2006), a successful math projects are an important part of the course of study is the result of effective planning and management. Along with teaching required material, we must provide meaningful projects that have real-life applications.

There are many ways we can incorporate projects into the classes. Perhaps the easiest is to select projects that support the unit you are teaching. For example, if we are studying a unit in geometry, project 'Designing a Flower a Bed', in which students work with rectangles, squares circles, and scale, will be useful. If we are teaching a unit on data analysis, project 'Election Poll', will supplement the instruction.

For students to work efficiently on math projects, they need a classroom that is logistically comfortable for problem solving. Tables are ideal however, if we do not have tables, we can push desk together. Either way, we should provide enough room between teams so that they can function as single entities without distractions from other group. Support math project activities in whatever we can. Bulletin boards,

corridor display cases, media center exhibits, and math fairs are just some ways to draw attention to the program.

Students learn flourishes in a conducive environment. One of the most important tasks as a teacher is to create a classroom filled with enthusiasm, the spirit of inquiry, and the desire to learn. The best classes are founded on the spirit of cooperation and energetic intellectual pursuit, in which students believe that everyone can learn and enjoy math. These are characteristics of math classes that have a positive atmosphere.

- The goals of the class are high enough so that students have to work hard, but not so high that they feel frustrated with math and its applications
- The classrooms is built on openness, fresh ideas, and sharing
- Students' work is prominently displayed
- The classroom is design to support inquiry and problem solving
- The classroom adheres to orderly procedures. Students appropriate behavior and follow the classroom rules
- Goal and objective are clear for students
- Classroom are fair and consistent
- The grading system is reasonable and equitable
- Math is connected to real-live problems and situations
- The teacher interacts with students and is a guide, nurtures, cheerleader, and provider of information
- Math is connected to real-life problems and situation
- Cooperation is encouraged
- Students are encouraged to consider and explain their reasoning during problem solving
- Sharing is encouraged, especially how students found solutions to problems
- Students and teacher become partners in learning mathematics

How to Assess Project-Based Learning?

There are several ways to assess project-based learning, i.e., written examinations, practical examinations, concept maps, peer assessment, self assessment, facilitators/tutor assessment, oral presentations, reports and student portfolios (Davis, 2011)

- **Written examinations**

Traditional written examinations can be conducted either as closed-book or open-book examinations. Questions should be designed to ensure transference of skills to similar problems or subject domains.

- **Practical examinations**

These examinations are used to ensure that students are able to apply skills learned during the course.

- **Concept maps**

Much of learning that goes on during problem-based learning is more than just a compilation of facts. As such, written examinations may not be an adequate measure of student growth. Requiring students to generate concept maps, in which they depict their knowledge through the creation of identified node and links, may present another option to determining their cognitive growth.

- **Peer assessment**

Because life outside the classroom usually requires working with others, peer assessment is a viable option to measure student growth. Providing students with an evaluation rubric often helps guide the peer evaluation process. This process also emphasizes the cooperative nature of the Project-Based Learning environment.

- **Self assessment**

An important element of problem-based learning is to help students identify gaps in their knowledge base in order for more meaningful learning to result. Self assessment allows students to think more carefully about what they know, what they do not know, and what they need to know to accomplish certain tasks.

- **Facilitators/tutor assessment**

The feedback provided by tutors should encourage the students to explore different ideas. It is important that facilitators not dominate the group, facilitate learning and exploration. Tutor assessment may consist of how successful individuals interacted with their group and their cognitive growth.

- **Oral presentations**

Because so much of work life revolves around presenting ideas and results to peers, oral presentations in problem-based learning provide students an opportunity to practice their communication skills. Presenting findings to their group, the class, or even a real-life audience can help strengthen these skills.

- **Reports**

Written communication is another skill important for students. Requiring written reports allows students to practice this form of communication.

- **Student Portfolios**

Samples of student work in various media forms provide a tool to show achievement and growth. This is a valuable way to collect and showcase authentic evidence of learning.

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Teacher Guide Project 1

Puzzling

Puzzle can make any kind of learning fun. Most students enjoy solving math puzzles, particularly those created by their peers. Puzzles may serve as an introduction to new material, provide practice in reinforcing skills and review concepts previously introduced. With a little guidance, students can design math puzzles of their own to share with their friends. They may even wish to publish their puzzles in math magazines or piece them in their portfolios.

Goal

Students will work individually or in pairs to create math puzzles to share with the class.

Math Skills to Highlight

Specific skills will vary according to the types and content of puzzles. Care should be taken to ensure that puzzles and their answer keys are accurate

Special Material/Equipment

Graph paper, rulers and pencil,

Development

When you introduce this project, many students may be at a loss as to how to create a math puzzle. A few days before starting the project, you might mention that the class will create mathematical puzzles and suggest that students consult math puzzle books, or their text. If you have examples of math puzzles created by students from other classes or examples from books, make them available. Prior to beginning the project, decide if you want students to concrete on a particular unit of study or topic, or if they will be permitted to create puzzles on any topic they wish.

- Start this project by explaining what students will do. Tell them that puzzles should be designed with a particular purpose or objective. They may be used to introduce new material, review previously learned skills, or practice computation. Some ideas for the content of puzzles include:
 - Learning definitions or properties

- Identifying figures
 - Learning relationships between definitions and numbers
 - Practicing computation or using calculators
 - Using percentages
 - Solving proportions
 - Applying order of operation rules
 - Using percentages
 - Finding perimeter, area, and volume
 - Solving equations
- Distribute copies of **Student Guide of Project 1** and review the information with your students. Graph paper can be used to draw boxes for puzzles
 - Inform students if you want them to concentrate on specific topics
 - Distribute copies of **Example of Puzzle**. Go over the sheet with your students, but emphasize that these are only some of the many types of puzzles they may create
 - Mention that students can add twist to common puzzles. A good example is a simple cross-number-puzzle. Although the puzzle may focus on the basic operations of addition, subtraction, multiplication, and division, a new wrinkle would be to have the puzzle solvers use calculators and work against a time limit. Another idea would be for students to compete against each other, with a champion being determined by the fastest time to finding a solution. Such a puzzle would be fun and exciting, and give students practice in working with calculators
 - Suggest that students create a rough or dummy version of their puzzles before attempting to complete them
 - Emphasize that all math must be accurate and that each puzzle should have an answer key.

Wrap-Up

Make copies of the puzzles, and allow students to work on them. This may be done as a class activity on completion of the project.

Extension

Compile copies of the puzzles in a class book. Make the puzzle book available to other students.

Students Guide of Project 1

Puzzling

Situation/Problem

You will create a math puzzle that other members of your class will try to solve

Possible Strategies

- Study examples of math puzzles in magazines and textbooks. Pay close attention to see how they are created.
- Determine your purpose or objective, and decide which type of puzzle you want to do

Special Consideration

- Gather the math facts that you will use. Be sure all your information is accurate
- Create a dummy version of your puzzle. Carefully sketch on a graph paper or a blank sheet how your puzzle will be set up
- If you are using a blank sheet, use rulers to divide distances equally
- Mistakes can be corrected using correction fluid.
- Consider creating your puzzle on a computer. Word finds, word scramble, and tricky questions may easily be done on computers.
- Double check your puzzle by exchanging your puzzle with a friend. He checks yours, while you check his.

To Be Submitted

- A final copy of your puzzle
- An answer key

Rough Ideas

Example of Puzzle

Puzzle

Math puzzle come in countless forms. Here are a few examples.

Word Find

Pick mathematical terms and arrange the words horizontally, vertically, backward, forward, and diagonally. Find all the math terms.

Solution

E R A U Q S
A V R B C U
E A E C F M
D O R N E X

E R A U Q S
A V R B C U
E A E C F M
D O R N E X

Magic Square

The sums of the numbers in each column, row and diagonal of the square are equal.
Find the missing numbers.

9	2	
4		8
5	10	

Solution

9	2	7
4	6	8
5	10	3

Cross-Number Puzzle

These puzzles are similar to crossword puzzles, except that digits are used.

Across

1. Perimeter of a square whose side is 7
2. $3 \times 6 + 3$

Down

1. The area of a square whose side is 5
2. 9^2
3. The volume of a cube whose side is 3

1	2		3	4
5		6		

Solution

1	2		3	4
2	8		2	
5		6		
5	1		7	

Mathogram

Letters are subtitled for the digits of numbers in this puzzle. The object is to find the digit represented by the letter.

Find what digit each letter represents

$$\begin{array}{r}
 \text{TWO} \\
 + \text{TWO} \\
 \hline
 \text{FOUR}
 \end{array}$$

Solution

$$\begin{array}{r}
 928 \\
 + 928 \\
 \hline
 1856
 \end{array}$$

Word Scramble

The letters of math words are mixed up.

Unscramble Each Word to Spell a Math Term	Solution
Enev	Even
Remip	Prime

Secret Message

Answers to a list of math problems provide a secret message. Possible answers (in numbers) are paired with letters of the alphabet. By finding the correct mathematical answer, the correct letter is discovered. Once all the problems are solved correctly, the message is revealed.

Solve Each Problem.

Match the answer with the letter of the alphabet to reveal a secret message.

C. $(6 \times 3) \times 2 = \underline{\hspace{2cm}}$

I. $4^2 = \underline{\hspace{2cm}}$

P. $(3 \times 5) - 1 = \underline{\hspace{2cm}}$

L. $8 : \frac{1}{4} = \underline{\hspace{2cm}}$

A. $4 \times 3 = \underline{\hspace{1cm}} \times 4$

R. $3.4 + 4.6 = \underline{\hspace{2cm}}$

E. $200\% = \underline{\hspace{2cm}}$

S. $5 \frac{1}{4} - \frac{1}{4} = \underline{\hspace{2cm}}$

Y. $3^3 = \underline{\hspace{2cm}}$

$$\begin{array}{cccccccccccc} \overline{18} & \overline{16} & \overline{36} & \overline{18} & \overline{32} & \overline{2} & \overline{5} & \overline{3} & \overline{36} & \overline{2} & \overline{2} & \overline{3} \\ \overline{5} & \overline{27} & \overline{3} & \overline{5} & \overline{14} & \overline{16} & & & & & & & \end{array}$$

Solution

C. $(6 \times 3) \times 2 = 18$

I. $4^2 = 16$

P. $(3 \times 5) - 1 = 14$

L. $8 : \frac{1}{4} = 32$

A. $4 \times 3 = 3 \times 4$

R. $3.4 + 4.6 = 8$

E. $200\% = 2$

S. $5 \frac{1}{4} - \frac{1}{4} = 5$

Y. $3^3 = 27$

CIRCLES ARE EASY AS PI

Project 2

Make Cookies for a Class Bake Sale

Name of Project

Make Cookies for a Class Bake Sale

Project Objectives

When students complete this project, they will be able to:

1. Understand and follow the directions in baking cookies
2. Bake cookies using the right measurement tools and baking equipment
3. Work together as a group to accomplish the desired goal
4. Use technology to design a print advertisement for the bake sale
5. Organize and interpret data of sold items by using a tally chart
6. Write a journal about their experience in baking and selling the cookies

Integration of Other Functional/Academic Skills

In completing the task, the students will be able to make use of skills in other subjects: mathematics, language arts and technology.

Subjects	Activities	Objectives
Mathematics	Use math skills to choose and use the appropriate tools in measuring, read the clock, and interpret data in a chart as necessary in completing the project	<ol style="list-style-type: none">1. Students record data by using tally chart.2. Students interpret data in a tally chart.3. Students tell time.
Language Arts	Understand and follow directions, compose a simple advertisement, and write a journal about the project	<ol style="list-style-type: none">1. Students give, restate, and follow two-step directions.2. Students use context to resolve ambiguities about word and sentence meanings.3. Students write brief narratives describing an experience.4. Students apply and follow basic capitalization and punctuation rules in writing their narratives
Technology	Use the computer in designing a print	<ol style="list-style-type: none">1. Students locate, identify and use some basic word processing terms, such as

	advertisement for the project.	<p>file open, menu bar, save, print.</p> <ol style="list-style-type: none"> Students locate and use keys in entering letters, number, and special symbols on the keyboard. Students explore internet resources to download clip arts and photos using teacher-created bookmarks.
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Activities

Day	Activities	Material	Duration	Procedure
1	Designing a Print Advertisement and a Tally Chart for the Bake ale	<ul style="list-style-type: none"> ▪ Computers ▪ Printers <p>Venue: Classroom</p>	1 hour	<ol style="list-style-type: none"> Present to the class a sample of an advertisement for a bake sale. Inform them about the necessary contents in it, such as the time, place, items sold. Let the students read aloud the items found in the advertisement. Ask the students the purpose of a tally chart. Inform them that they are to create one to organize and interpret the different kinds of cookies sold in the bake sale. Show the students the programs or applications that they may use in designing the print advertisement and making the tally chart. Present the websites where they can download photos or clip arts to enhance their work. Divide the class into groups of four (this will be their permanent group). Give them enough time to conceptualize and develop their print advertisement and make the tally chart. Evaluate their works before having them printed. Peer evaluating may be done, or the teacher alone may do this.
2	Baking of the	<ul style="list-style-type: none"> ▪ Measuring 	1 hour	<ol style="list-style-type: none"> Write on the board a simplified

	Cookies	<ul style="list-style-type: none"> cup and spoon ▪ Cookie sheet ▪ Baking tray ▪ Cookie mix ▪ Oven <p>Venue: Kitchen</p>		<p>version of the procedure in baking the cookies. Guide the students as they read aloud teach step. Ask the students if there are terms they find confusing, and unlock difficulties if necessary.</p> <ol style="list-style-type: none"> 2. Present to the students the measuring cup and spoons to be used. Familiarize them with the numbers found in each tool, and model how they are used by showing sample measurement for ingredients (such as water or flour). 3. Divide the class into groups of four and observe them as they go about the procedure. 4. Preheat the ovens. (Students are not to touch hot surfaces on the oven.) Afterwards, place the cookie trays inside, and instruct the students to be aware of the time when the cookies are done. 5. Gather the cookies once they are well-done. Let them cool before storing them in containers, in preparation for the bake sale the next day.
3	Bake Sale	<ul style="list-style-type: none"> ▪ Cookies in trays ▪ Print advertisements ▪ Tables and chairs ▪ Tally chart <p>Venue: Cafeteria</p>	30'	<ol style="list-style-type: none"> 1. Prepare the group's booth, and put up the advertisement. A bell will be rung to signal the beginning of the bake sale. 2. Assign two members from the group to tally the cookies sold (there are two types of cookies in each booth). The other two members are in charge of serving the cookies ordered, and in receiving and giving the change for each payment.
4	Evaluation of the Activity	<ul style="list-style-type: none"> ▪ Tally chart ▪ Notebook ▪ Writing 	1 hour	<ol style="list-style-type: none"> 1. Present to the class the list of activities to be done for the day: <ol style="list-style-type: none"> a. Interpreting the data in the tally

		<p>materials</p> <p>Venue: Classroom</p>	<p>chart</p> <p>b. Presenting an oral report about the result of their group’s sales, with reference to the tally chart</p> <p>2. Let the students join their groups. A facilitator may be chosen to present to the group their tally chart. They must interpret the data gathered by studying the items in the chart. These guide questions may be used: <i>Which type of cookie was sold more? Which type of cookie was sold less? What is your analysis about the result of your sales? Would you consider your group a success in the bake sale? Why or why not?</i> One reporter for each group will be tasked to share to the class their group’s evaluation of their sales.</p> <p>3. Grade each group based on rubrics for each item (print advertisement, the cookies, oral report).</p> <p>4. Ask the students to write a narrative about their experience in completing the project. They will be given an individual grade for their journal.</p>
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A Few More Things About the Project

After the activity, the students will be able to understand that:

1. Basic math skills such as counting, collecting, organizing and analyzing data are necessary in producing good results in a project.
2. Collaboration and teamwork, critical thinking, effective oral and written communication skills are necessary in conceptualizing and developing a successful group project.