Research into Practice:

MATHEMATICS

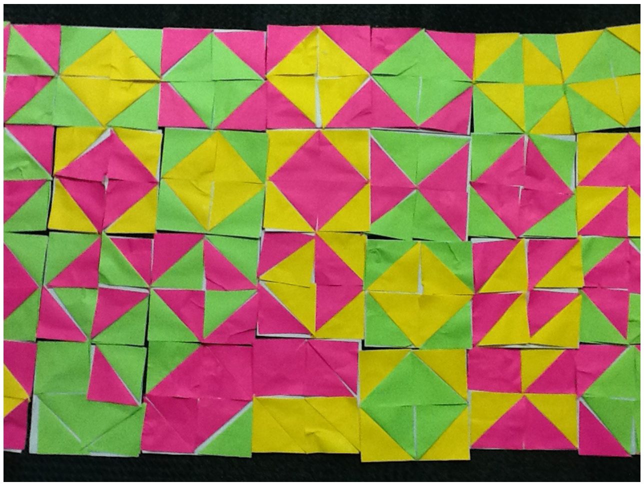
PROJECTS: Opportunities for Conceptual Connections, High-Interest Tasks, and Differentiation

BY DR. JUANITA COPLEY

It was the end of the school year and it was our last math team meeting. As the math coach, I had asked everyone to bring one example of how teachers in their grade level had "engaged students in meaningful learning through individual and collaborative experiences," a teaching and learning principle we had studied during the year (NCTM 2014). Their reflections are very exciting.

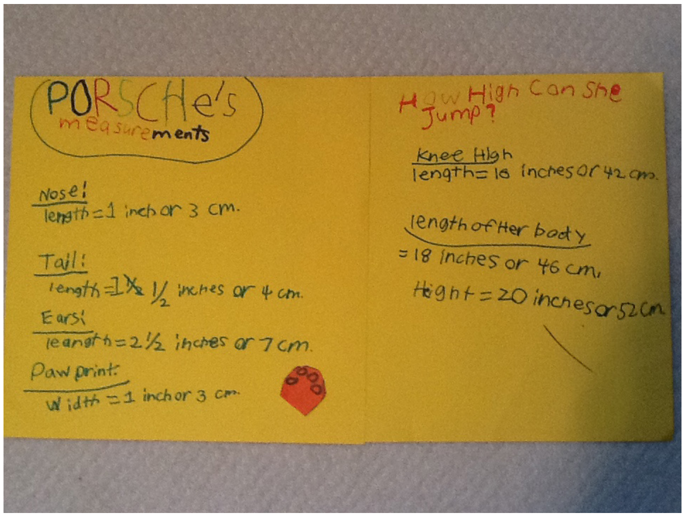
"Our roller coaster project was fantastic! It all started with three boys making a model of a roller coaster, using a marble for the coaster and cardstock for the track. By the end of the month, fifteen teams entered the contest for the fastest coaster (inches per second), the coaster that traveled the greatest distance (measured in inches), and the coaster that traveled for the longest time (measured in seconds). Lots of meaningful practice measuring and calculating!"

"Several of my artistically-oriented students covered large squares with right triangles at a geometry center. When they displayed their work, others contributed similar squares, resulting in a large quilt hanging outside of our classroom and a question for everyone: How many triangles can you find?



"My example illustrates engagement for just one special student. Jonathan was a quiet child and was not easily engaged in math activities. When he mentioned that he had a new puppy, I invited him to describe the puppy using as many numbers as he could and to share the results. All of us were impressed

with his detailed work and his accurate measurements. Importantly, his project prompted many interactions with his peers about their pets and size comparisons."



As these short examples illustrate, projects are an excellent way to connect students' interests with high-quality mathematics curriculum and real-world events. If appropriately implemented, projects provide opportunities for the application of mathematics knowledge and skills.

WHAT ARE WELL-DESIGNED PROJECTS, AND HOW CAN THEY BE APPROPRIATELY IMPLEMENTED IN ELEMENTARY CLASSROOMS?

While there are varied degrees of including projects in the mathematics curriculum, ranging from a total standards-based curriculum with no projects whatsoever, to a project-only approach with standards correlated as the project develops, the approach that is most easily implemented is a "mixed model." In the mixed model, students work through a standards-based curriculum that is infused throughout with project-based work designed for individuals or small groups of students. Each suggested project involves a process and a product that is directly connected to mathematics standards and curriculum. A well-designed project offers some level of student-centered choices within specified parameters (Zhao 2012). There are three indicators of a well-designed and appropriately implemented project:

1. The project maintains strong conceptual connections between the mathematics content standard covered in the project and the mathematics concepts developed in the project task.
2. The project involves rich, high-interest tasks.
3. The project offers several possible pathways for differentiation.

1. Conceptual Connections

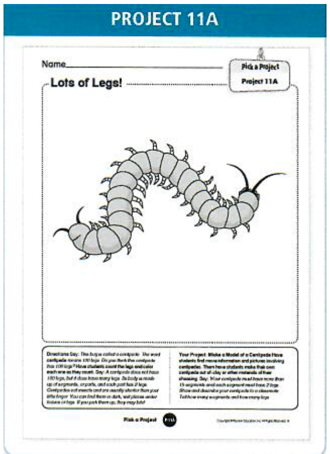
Recent mathematical standards that are being implemented throughout the nation are a "balanced combination of procedure and understanding." The *understanding* expectations are often especially good opportunities to connect the practices to the content. One of my favorite definitions for *understanding* clearly states, "We understand something (or a concept) if we see how it is related or connected to other things we know" (Lambdin 2003). These connections are also important as our brains process new information and file it for future use (i.e., store it in our memory). If students are to develop the understanding that is necessary for mathematics, it is important for teachers to encourage students to make connections between concepts, procedures, and operations.

Well-designed projects, then, are directly connected to important mathematics concepts. These connections will be clear and explicit to both the learner and the teacher. Hodgson (1995) suggests that an ability to form and use connections empowers students as problem solvers. He recommends that classroom activities (e.g., *projects*) "prepare students both to establish new connections and to use established connections in problem settings" (p. 21).

WHAT DOES A WELL-DEFINED PROJECT LOOK LIKE?

The examples in Figures 1 and 2 demonstrate the connections between the project introduction (shown by the picture and question), the mathematics concepts developed in the project (illustrated in a blackline master), and the mathematics content standard (identified from the specific content standard) covered by the project.

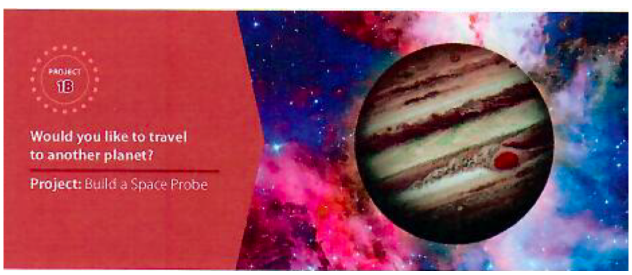
Kindergarten Project: Make a Model of a Centipede



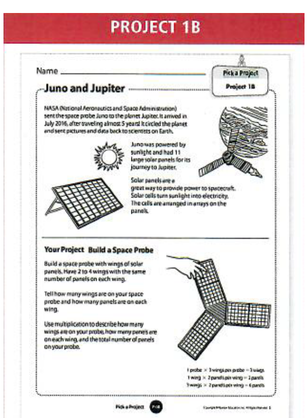
Mathematics Concepts: After talking about the word centipede and its meaning, students count the legs of the pictured bug to determine if it is a centipede. Then students create their own model of a centipede according to the information given about "what makes a centipede a centipede."

Source: ***enVision***® *Florida Mathematics ©2020*, Grade K (Charles et al., 2020)

Figure 1. Kindergarten project uses Mathematics Content Standard: Count to 100 by ones and by tens.



Grade 3 Project: Build a Space Probe



Mathematics Concepts: In this topic, students work with equal groups as one model of multiplication. In the suggested project, students make equal groups of panels on 2 to 4 wings on their space probes. Then they use different equations to describe the wings and the panels on the probe.

Source: ***enVision***® *Florida Mathematics ©2020*, Grade 3 (Charles et al., 2020)

Figure 2. A project for third graders as they learn to use multiplication and division to solve word problems.

Mathematics Content Standard: Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.

2. Rich, High-Interest Tasks

Student choice is an important aspect of well-designed and appropriately implemented projects. Students at all levels learn best when they are allowed to investigate topics that appeal to their interests, make decisions about their active involvement, and create their own methods of representing and communicating ideas. NCTM's 73rd Yearbook, *Motivation and Disposition: Pathways to Learning Mathematics* (Brahier and Speer 2011), reported important purposes for the use and development of high-interest tasks, as follows:

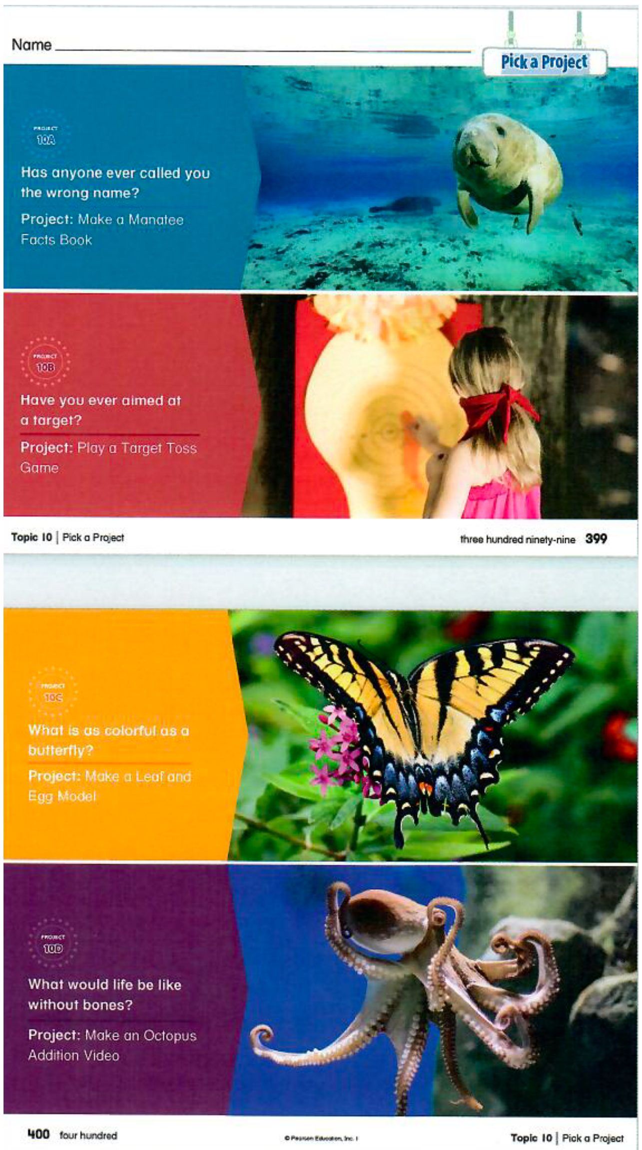
- Motivation involves both extrinsic and intrinsic goals, emotions of interest and curiosity, and self-efficacy, a feeling that the student is capable of doing the project.
- When given a task, students can exhibit attitudes or dispositions that illustrate motivation, perseverance, flexibility, and value/usefulness.
- Student-friendly contexts (i.e., high-interest tasks) "can be used to capture the attention of students, thus motivating them to develop mathematical concepts" to solve problems (Brahier 2011, p. 8).
- When instruction involves high-interest activities, these activities result in better engagement and higher self-efficacy.

Other sources offer additional support for the importance of rich, high-interest tasks.

- Young children learn best when they are interested and excited. Research reported by the National Research Council (2009) recommends that early childhood educators offer children play-based, integrated mathematical experiences (e.g., projects).
- Meaningful projects powerfully activate students' need-to-know with an engaging entry event (McCormick and Twitchell 2017).
- Language and the ability to communicate learning can be made easier if the communication is interesting, relevant, belongs to the learner, and the learner chooses to use it because he or she has the power to do so (Clark 1998).

HOW CAN STUDENT CHOICE AND HIGH-INTEREST TASKS BE DESIGNED AND IMPLEMENTED WITHIN A MATHEMATICS CURRICULUM?

The following examples can be used to answer this question. Shown below are some project choices that students have within two specific grades of ***enVision***® *Florida Mathematics ©2020*. (Charles et al., 2020) Students have the option of choosing one or more tasks (projects); they also choose to work alone, with a partner, or in a small group.



Source: ***enVision***® *Florida Mathematics ©2020, Grade 1 (Charles et al., 2020)*

Figure 3. Examples of project choices for first graders as they learn to use models and strategies to add tens and ones.

Source: ***enVision***® *Florida Mathematics ©2020, Grade 4 (Charles et al., 2020)*

Figure 4. Examples of project choices for fourth graders as they learn about lines, angles, and shapes.

3. Pathways for Differentiation

Every student is a unique learner. Students differ in their previous experiences; they have different interests, prefer different ways to learn, have different family support systems, have different backgrounds and cultural norms, exhibit different attitudes, and so on and thus require different teaching methods. How can a teacher provide the support that is needed for every student in class? The process of differentiation is one partial solution. “Differentiated instruction implies a purposeful process for adapting the teaching and learning processes of the classroom to accommodate the needs of all learners” (Murray 2007, p. 1). Techniques or pathways for differentiation provide “shared mathematical contexts” for diverse learners (Gearhart and Saxe 2014), while at the same time providing differentiated support or challenge as necessary. Differentiated instruction addresses the equity principle (NCTM 2014) and the issue of access, which advocates “all students have access to a high-quality mathematics curriculum” while emphasizing the importance of “high expectations” to “maximize learning potential.”

Projects are a tool for differentiated instruction; they are not the only tool, but projects can help provide an equitable mathematics environment for all learners. Research and educators suggest several different methods for differentiation that apply to the use of projects.

- Use multiple entry points, e.g., flexible groupings and student choices for styles, activities, numbers, or presentation types (Christenson and Wager 2012).

- Rearrange lesson components by beginning with a question or a problem and allowing students to investigate the problem before teacher support is given (Drake et al. 2015).
- Vary projects by activity type. Drawings (Woleck 2001), building creations (McCormick and Twitchell 2017), and experiential investigations are just a few of the activity types that can be part of a project.
- Encourage multiple representations and strategies BEFORE introducing a preferred solution strategy (Drake et al. 2015).
- Use varied representations to share the results of a project and to illustrate the extent to which appropriate internal representations for mathematical concepts have been developed (Miura, 2001).
- Have students share project activities and results with their classmates in different ways, which may involve reading, writing, telling/showing, modeling/demonstrating, discussing, drawing, viewing/observing (Fonzi and Smith 1998).

The examples shown in Figures 5 and 6 demonstrate how project options for a given mathematics topic, with different activity modalities and varied final products, can help the teacher to implement differentiated instruction.

	Varied Engaging Contexts	Varied Activity Modalities	Varied Final Products
6A	Snakes	Research	Model
6B	World	Collect data	Pictures
6C	Cities	Draw maps	Map
6D	Space	Perform	Skit

Source: ***enVision***® *Florida Mathematics ©2020, Grade 2 (Charles et al., 2020)*

Figure 5. Examples of variations in the project options offered to second graders for Topic 6: Fluently Subtract with 100.

	Varied Engaging Contexts	Varied Activity Modalities	Varied Final Products
2A	Reptiles	Collect data	Labeled drawing
2B	Theme parks	Investigate	Brochure
2C	Food	Plan	Model
2D	Traveling	Write and draw	Journal

Source: ***enVision***® *Florida Mathematics ©2020, Grade 5 (Charles et al., 2020)*

Figure 6. Examples in variations in the project options offered to fifth graders for Topic 2: Add and Subtract Decimals to Hundredths.

3. Conclusion

Principles to Actions (NCTM 2014, 5) states, "An excellent mathematics program requires effective teaching that engages students in meaningful learning through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically." Projects, like those described in this paper, provide opportunities for students to engage in rich, high-interest tasks that require conceptual connections between math concepts and other curricular areas as well as meaningful sense-making experiences. For teachers, projects provide a variety of pathways for differentiating instruction for individuals and groups of students as they teach mathematics. The result of a strong standards-based curriculum infused with mathematics projects is "...effective teaching that engages students in meaningful learning."

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